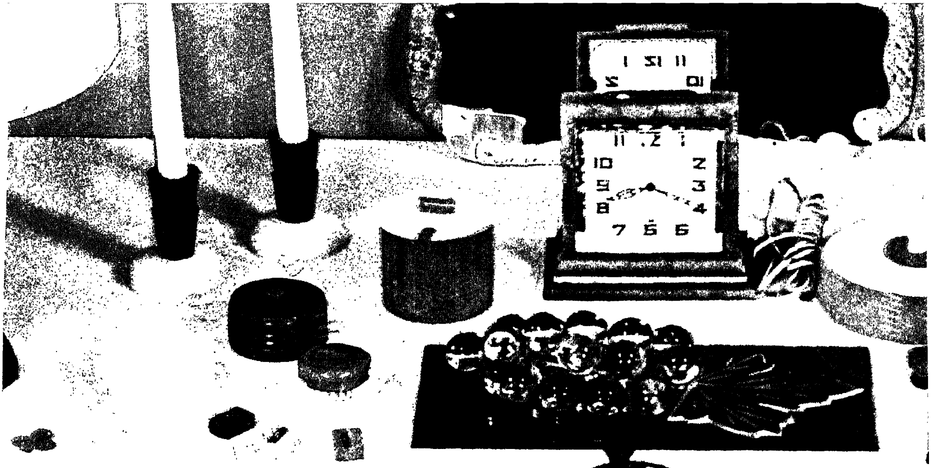

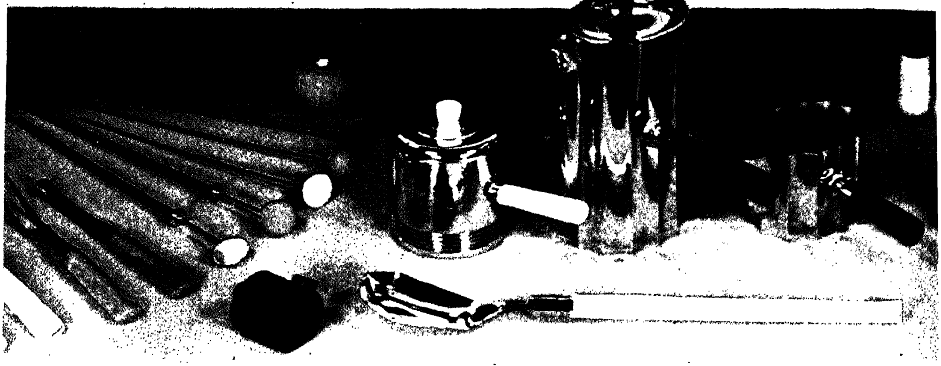

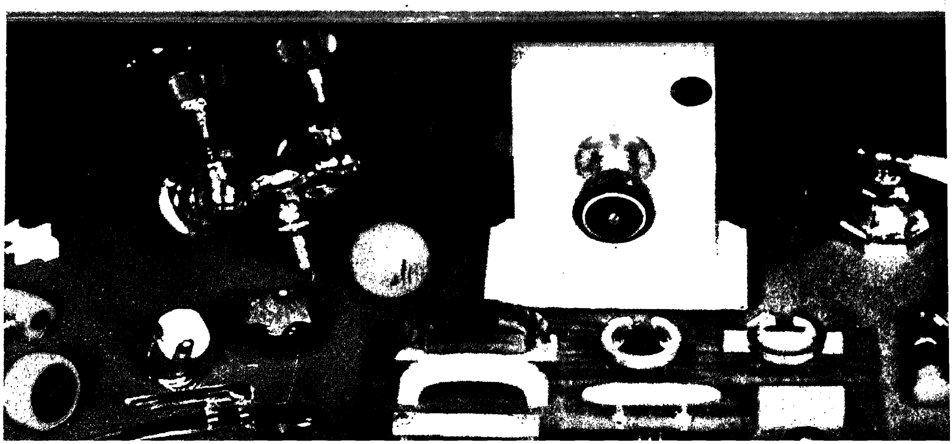

PLASTICS
PROBLEMS AND PROCESSES

By

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SECOND EDITION
Third Impression

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INTERNATIONAL TEXTBOOK COMPANY
SCRANTON, PENNSYLVANIA

PRINTED IN THE UNITED STATES OF AMERICA

First Edition
First Printing, December, 1938
Second Printing, August, 1939

Second Edition
First Printing, September, 1942
Second Printing, May, 1943
Third Printing, October, 1944

INTERNATIONAL TEXTBOOK PRESS
Scranton, Pennsylvania

24597

FOREWORD

The astonishing growth during the last few years of the commercial use of cast resinoids, commonly called plastics, has resulted in the production of that commodity in quantities and at costs which have made it easily available to devotees of handicraft everywhere. Thus it has been seized eagerly by alert industrial arts instructors, who have recognized in plastics the almost perfect medium for the development of technical skills and intelligence and the encouragement of creative expression. For here the utilitarian values of strength and adaptability to an infinite variety of uses are supplemented by the fascinating beauty of the colorful resinoids.

The enthusiasm with which this new material is being greeted by instructors and pupils alike, and the fact that neither teaching personnel nor laboratory equipment need be altered to permit working with plastics, add impetus to a trend well under way—the inclusion of courses in plastics as a vitalizing and permanent addition to the industrial arts curriculum.

The present textbook, first in its field, is the product of actual classroom experience coupled with diligent and exacting research. Its authors are thoroughly competent artisans, highly trained, and widely recognized for their success as instructors. In their book not a single activity has been suggested that has not been developed in their own laboratories under normal classroom conditions.

It has been the privilege of the writer to have been associated with the authors of this textbook during the entire period in which they have developed their plastics courses, to have had daily access to the laboratory of one of them, and to have witnessed the enthusiastic interest of the boys and girls enrolled in the classes and of countless visitors—both professional and lay—who have investigated the work. It is his confident belief that the textbook here submitted will render a definitely needed service in the important field of industrial arts.

M. E. WILLIAMS,

Principal, W. H. Kirk Junior High School,
East Cleveland, Ohio

FOREWORD

Second Edition

From milk, air, coal, and farm waste, come strange chemicals which join to make a new material. Neither wood, metal, cement, resin, nor clay, this new material has many discovered and hundreds of undiscovered uses—the field seems boundless. Plastics have changed our mode of thought. For generations we have been thinking of wood *as wood;* now, through impregnation with inexpensive chemicals, we find emerging a new material which can be bent, compressed, turned like metal, or molded, with few of the former characteristics of wood. From this one example, what a world of new ideas seems to form about this wood which is not wood!

It is readily seen that these and many more new plastics materials need fresh concepts adapted to their qualities. No longer can a wood-turning design or an art metal pattern be applied to plastics and be considered within the bounds of good taste. We must think of new forms of organization and new designs, particularly adapted to the plastics crafts.

The authors have made a sincere attempt to avoid false applications of design, the pitfalls of dictation and of imitation made possible by copying the designs of others. These vicious habits are usually the by-product of an incomplete teacher education, false ideals, mental stagnation, or a perfectly human tendency to follow the easiest pathway, often the refuge of the over-taxed teacher.

The young craftsmen who wrote this book are earnest and are themselves teachers who, through empirical methods, have proved the practicality and value of the problems presented. Sensitive to educational needs, they have encouraged that creative effort which is all too rarely found in industrial arts courses.

I have worked with the authors in a cooperative spirit with the intention of discovering the best avenues of design organization for plastics. Each design has been checked with painstaking care, with the idea that it will serve as a creative stimulus to be considered as a guide leading toward creative effort.

It is possible to conceive a period of post-war reconstruction with an age of plastics equaling in importance that of iron. Automobiles, airplanes, furniture—yes, and possibly houses, may be of plastics origin. To meet this hypothetical condition and also to understand the present state of the plastics arts, the authors have ably presented tools, processes, and materials as a component part of the general educative process. Students by themselves may discover new methods of treating plastics design, new avenues of approach which may be developed in sympathy with the material, for it is felt that the possible boundaries of plastics decorative treatment are far from established.

Either for the hobbyist or the pupil, this book has set up a sound method of approach to this colorful, texturally pleasing, and responsive material, which will lead to the forming of attractive articles directly related to our social environment, fostering and encouraging the art of good living as an essential part of general education.

WILLIAM H. VARNUM

Chairman, Department of Education
University of Wisconsin, Madison

PREFACE

Plastics is no longer a term shrouded with mystery. There are, however, a great many things about the material which are not known or understood by the consumer, while even the manufacturer has difficulty in keeping up with developments in the field of plastics. The magnificent manner in which the plastics industry is meeting current demands may suggest the part it will play in the future life of everyone.

This book has been designed to meet the needs of several groups: pupils in junior and senior high schools, students in colleges and universities, professional people (such as teachers, lawyers, and dentists), home craftsmen, manufacturers, and laymen. An attempt has been made to introduce readers to the whole field of plastics without including an abundance of difficult technical information.

Many changes have been made in this edition to answer questions which have been asked and to meet some of the problems which have been presented to the authors. Chapter 1 of the first edition has been expanded to three chapters and much new information has been introduced. An entirely new chapter, "Design for Plastics," has been added to the book. Many of the problems have been redesigned and several entirely new problems are presented. A total of sixty-five plates of problems and two hundred and fifteen separate designs are included. Many of the illustrations appear for the first time in this edition.

The writers are greatly indebted to Professor William H. Varnum, Chairman of the Department of Art Education, The University of Wisconsin, for his many helpful suggestions on Chapters 8 and 9 and for his cheerful editing of Chapter 7. To the following companies the authors gratefully acknowledge their indebtedness for assistance given in assembling experimental materials or for supplying photographs which appear as illustrations in the book:

American Insulator Co.
New Freedom, Pa.

Atlas Press Co.
Kalamazoo, Mich.

Bakelite Corp.
New York City

Breskin Publishing Co.
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Brodhead-Garrett Co.
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Chicago, Ill.

The appendices have been prepared to solve many problems for users of this book. Supplementary notes on types of plastics, technical data, historical facts, production records, supplies and equipment suggestions, and a glossary of difficult terms are arranged to assist students and craftsmen. All contents are systematically organized and indexed.

D. E. M.
C. W. P.

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PLASTICS

PROBLEMS and PROCESSES

Chapter 1

The Story of Plastics

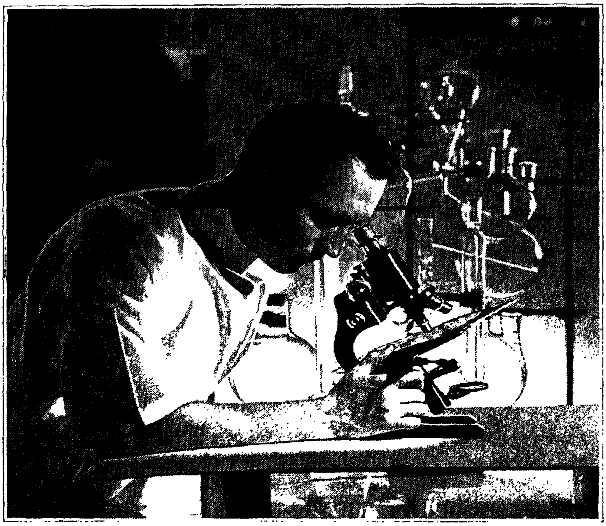
THE ROMANCE OF SYNTHETIC PLASTICS is a fascinating one, not only because of what may already be told, but because the story is still unfolding and even more amazing achievements are in prospect. Since the depression of 1929, a new material has been born to a modern world—a material of surpassing beauty. It has emerged from the chemist's test tube in a flashing display of color, beauty of pattern, and brilliance of finish. It opens for every person the opportunity to decorate his home and ornament his person in a manner impossible even to Solomon in all his glory.

The age in which we now live has been termed everything from the "Electrical Age" to the "Plastics Age." Man continues to seek out ways of doing new things, better ways of doing old things, and new ways of remaking the materials of nature. As competition in industry becomes more intense, industry depends more and more upon chemistry for solutions of its problems. Many chemists are interested not only in searching out new elements, but in seeking out new combinations for the elements already known. These facts have led one industrial firm [1] to adopt the slogan, "Better Things for Better Living Through Chemistry." Another firm is devoting 40 per cent of its budget to chemical research leading chiefly to the developments of plastics.

There was a time in the development of our country when little attention was given by industry to the aesthetic side of life. Drab houses, commonplace highways, and structures of monotonous masonry were built. Cities were laid out with little consideration for anything other than the "practical." Many of these just grew like Topsy, and long-range planning was practically unknown. More recently, however, *beauty* is claiming its share of attention in industrial planning. Early in his career, Henry Ford is said to have been

[1] E. I. du Pont de Nemours & Company, 350 Fifth Ave., New York City.

responsible for stating that he would not give a nickel for all the art in the world. Ford began the new era by reversing his judgment and stating (16-28)[2]: "Design will take more advantage of the power of the machine to go beyond what the hand can do, and will give us a whole new art." With the advent of more effective dyes in this country, after World War I, far more color has been emerging in



(Courtesy of the E. I. du Pont de Nemours & Company, Inc.)
Figure 1. Chemistry—A fundamental science in the plastics industry.

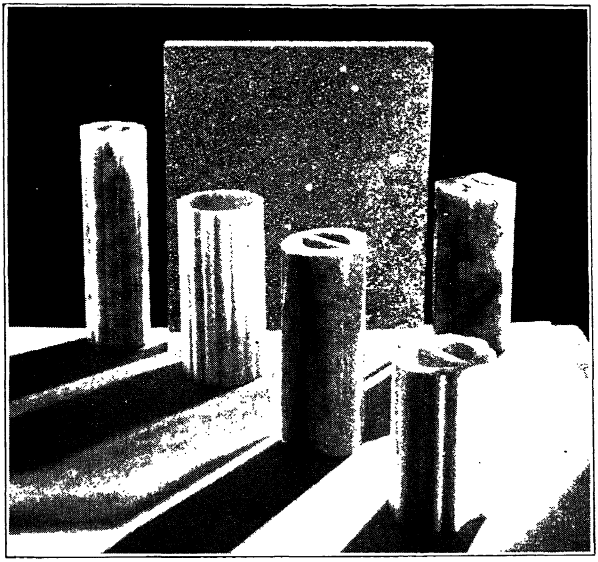
industrial products. One manufacturer[3] has applied the phrase "The Gem of Plastics" to its products. What retailer does not know that colorful merchandise has most "eye value"?

Numerous articles which possess sheer beauty, pleasing cloudiness, delicate transparency, jet black coloring, and exquisite lustre may be found in almost any large department store. Articles bearing these qualities were once possessed in the form of jade, onyx, crystal, and amber, only by the privileged few. During their early develop-

[2] References to the bibliography will be made in this manner throughout the book. The first number indicates the item, the second number indicates the page of work cited.

[3] Catalin Corporation, One Park Avenue, New York City.

ment plastics were judged, as has been true of many other things, in terms of the degree to which they imitated older materials that were considered beautiful and valuable, such as quartz, onyx, and pearl. More recently, however, there has come a realization that plastics are beautiful not merely because they resemble more expensive materials, but because they possess beauty *in their own right.*



(*Courtesy of the Catalin Corp.*)

Figure 2. "The Gem of Plastics."

THE MEANING OF PLASTICS

A dictionary defines "plastic" as an adjective meaning "capable of being formed or molded." Plastic materials, as such, are not new. Noah used a plastic material, pitch, for caulking his ark; and Moses's mother used a similar material for daubing the little boat placed among the bulrushes. Natural materials such as pitch, rosin, tar, amber, and shellac have played very important parts in past civilizations and are still important in our own.

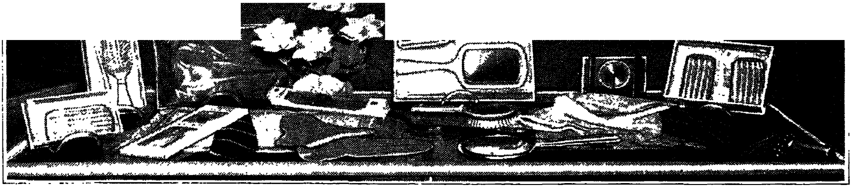
Additional materials were made possible by chemical combinations as time went on. At some stage in their development, such

new materials can be referred to as being *plastic,* but in the search for a word to describe them, they and the articles fabricated from them have become known as *plastics.* The term is somewhat misleading, for many of the manufactured materials are not "plastic" at all, because they have been made infusible and insoluble by chemical action.

Figure 3. Samples of synthetic plastics in a variety of types and shapes.

Plastics describes the synthetic materials just mentioned, but another problem presents itself. There are occasions in which parts made from plastics need a reference—an adjective form of the noun *plastics* is necessary. Simonds (72-33) makes a convenient distinction by using the same spelling, "plastics," for the adjective form. The

same spelling may represent, too, both singular and plural noun forms. The old meaning, "capable of being formed or molded," is thus retained for the adjective "plastic." A *plastic* part then becomes a part which may be formed or molded, and a *plastics* part becomes a part made of plastics.



(Courtesy of the Scranton Dry Goods Co.)

Figure 4. Commercial exhibit of plastics articles.

A few years ago the terms "plastics" and "Bakelite" were synonymous in the understanding of the average man. "Bakelite," however, is the trade name for only one type of plastics. To say the least, plastics is a complex material and difficult to define. Technical men cannot agree upon the limits of the field. Chemists have defined the word in technical terms, but to the layman this definition would mean little. There are certain facts, however, about plastics upon which all will agree.

1. Plastics are synthetic.

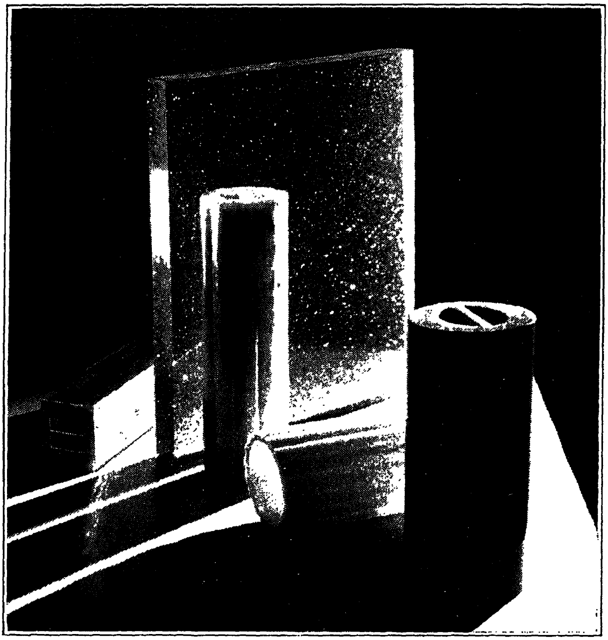
2. All plastics start from an initial stage which is identified by a (synthetic) binder.

3. The resinous material at a later stage must be either plastic or liquid (capable of being poured for casting).

4. A later development results in a solid material by curing or drying.

5. The final stage is usually reached through a rearrangement of molecules by polymerization or condensation.

6. The resulting material bears little or no resemblance to the original raw materials—the process has produced a new material with a new chemical structure.



(*Courtesy of the Catalin Corp.*)

Figure 5. Cast resinoid from which articles can be fabricated.

THE HISTORY OF PLASTICS

Shellac, a resinous gum produced from the secretion of an insect found in the Orient, more closely resembles the resinoid of modern plastics than any other natural resin. Shellac and other natural resins have their own field of use, and because of their particular properties or because of their greater economy have not been replaced. Synthetic plastics have a much shorter history. Their earliest development dates back to the middle of the nineteenth century. Progress from that time on has been continuous but rather slow until recent years. It was not until the beginning of the twentieth century that full commercial possibilities for synthetic resinoids were seen. Experimentation and progress were still slow until World War I. Additional stimulus was given by the economic depression of 1929. Progress has been spectacular since that time.

The first synthetic organic plastics is generally conceded to have been *styrene*. This material was produced in a chemical laboratory in 1839. In 1845 it was described accurately by Blythe and Hoffman. In 1846 Schonbein, an English teacher of science, discovered a nitro-cellulose compound while teaching in Switzerland. Work on the resinoid was done while the materials were in solution, and no commercial significance was attached to them.

It is to John Wesley Hyatt, a young printer (later of roller-bearing fame), that the credit goes for the first American plastics—*cellulose nitrate,* produced in 1868. This product resulted from his efforts to win a prize of $10,000 offered for a satisfactory substitute for ivory to be used in the manufacture of billiard balls. Hyatt used camphor both as a solvent and as a plasticizer on cellulose (from cotton linters) treated with nitric acid, and a plastics solid was born. The first American plastics patent was issued in 1869. The discovery resulted in the organization of the Albany Dental Manufacturing Company, in 1870. Because of a demand for a variety of products, the Celluloid Corporation of Newark, New Jersey, was organized some two years later. "Celluloid," one of a series of trade names for cellulose-nitrate products, is still produced.

The second plastics material, *casein,* was developed in 1890. Adolph Spitteler, a German, discovered a shiny solid material when he mixed sour milk and formaldehyde. Spitteler and a German printer, W. Kirsche, worked independently for a while but later collaborated to secure a patent in 1900. Casein plastics have been produced in bulk form since that time. The Galalith Company commercialized the process.

The third commercial plastics, phenol-formaldehyde, has been developed since 1909. Phenol was condensed with formaldehyde in the presence of a catalyst to form a resinoid. Credit for the discovery is usually given to Dr. Leo Baekeland, a Belgian scientist of Yonkers, New York; although Redman and Aylesworth in the United States and Raschig in Germany were working on the same process at the time. The first patent for phenolic plastics was issued in 1909. Three American companies were born: the Bakelite Company, the Redmanol Company, and the Condensite Company. As a result of patent

litigation, these three companies merged into the Bakelite Corporation in 1922. Westinghouse developed "Micarta" for laminated gear wheels. Following expiration of the original phenol-formaldehyde patents in 1926, many other companies have marketed these plastics under a variety of trade names.

A natural plastics, *bitumen plastics,* parallels very closely the development of the phenolics. The bitumens were developed to obtain a moldable, heat-resisting solid for use in the electrical and automotive fields as an insulator. During the post-war period, around 1923, the bitumen plastics surpassed the phenolics in production. In recent years, however, the volume has decreased to a small fraction of peak production. The phenolics had developed to a point where they were superior in every respect except heat resistance.

A moderate degree of plastics consciousness developed in the United States during World War I. A period of active development in production and public attention began with the appearance of *cellulose acetate* plastics in 1927. These plastics had been known in chemical laboratories for decades, but the first cellulose acetate patent was issued in 1903. The acetates came into the picture to avoid the fire hazards of cellulose-nitrate plastics. Over a four-year period, from 1931 to 1935, production of acetate plastics increased from 100 tons to 5500 tons.

In 1929 another plastics, *urea-formaldehyde,* entered the industrial picture. In this year an American firm purchased the patent rights of a foreign organization. At about the same time, the president of the Toledo Scales Company, H. D. Bennett, sponsored a series of fellowships at the Mellon Institute of Industrial Research. "Plaskon," "Beetle," and "Unyte" were early competitors. These urea plastics extended the unlimited color possibilities of the cellulose derivatives (thermoplastics) to the thermosetting group.

In 1928 *vinyl resinoids* were introduced by the Carbide and Carbon Chemicals Corporation. The vinyl compounds were known by chemists as early as 1838. Staudinger developed vinyl-acetate in Germany in 1927.

In 1931 *acrylic resinoids,* produced by the Röhm and Haas Company, entered the industrial picture. As early as 1843, Redtenbacher

produced a solid substance by oxidizing acrylic acid. A clear, hard, transparent mass resulted from the action of sunlight. *Methyl metha-crylate* resinoids were produced first by the E. I. du Pont de Nemours & Company, Inc., and later by the Röhm and Haas Company.

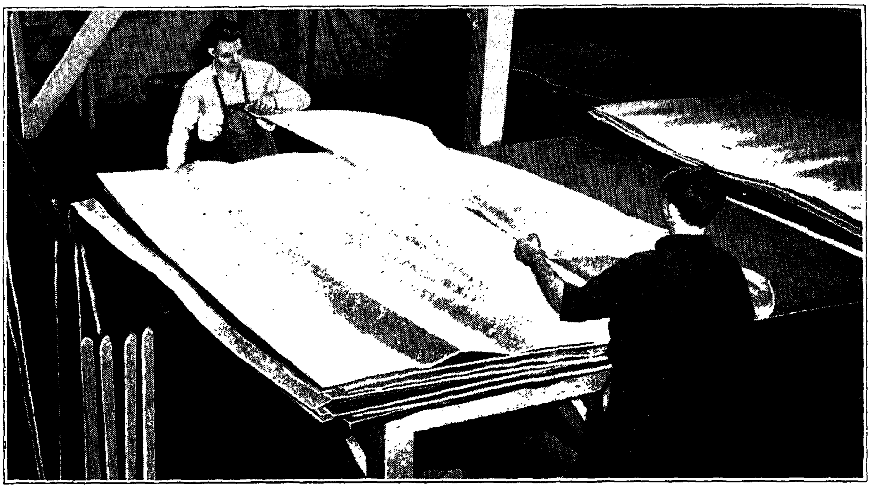
In 1937 the Dow Chemical Company introduced "Styron," a synthetic material derived from *styrene*. A research on polystyrenes was published by Dr. F. Matthews, an Englishman, in 1911. Many new plastics and variations of the old plastics have made their appearance within recent years. Synthetic resinoids for surface coating have made made tremendous strides. One type, *alkyd,* had reached a production of 61 million pounds in 1937, according to Delmonte (23-16). Kline (50-44) sets the figure at 40 million pounds in 1938. This "is the largest single outlet for synthetic resins." Surface coatings are manufactured from most of the resinoids already mentioned.

To record the history of the synthetic resinoids in detail would require a volume. Only those of greater importance at present have been mentioned. Various influences affect the production of each type. All are produced because the properties of each one vary slightly from the others or because of the availability of raw materials. Scarcity of a particular material may cause one of the minor or more expensive plastics to forge to the front in production.

RECENT DEVELOPMENTS IN PLASTICS

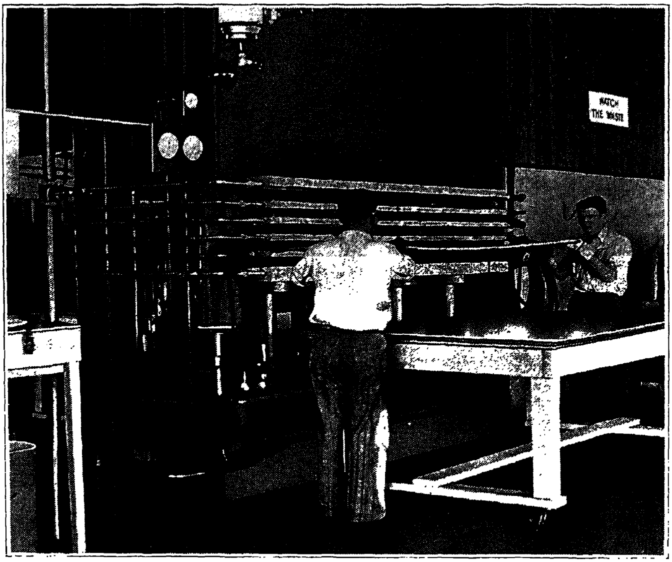
Perhaps no other industry has enjoyed such consistently rapid growth over a period of two decades as has the plastics industry. In fact, the industry is making such rapid progress that a part of the information contained in this book will be out of date by the time it comes from the press.

Synthetic adhesives have made possible the laminating of wood and other materials with a waterproof bond. Plywood bonded with these adhesives can be used for concrete forms, sheating, and exterior walls in the building trades. In the operations shown in Figure 7 a pressure of approximately 200 pounds per square inch at 280 to 300 degrees F is applied. The phenol-formaldehyde film adhesive yields a bond which withstands boiling water, mold, heat, and freezing. Sheets of plywood as large as 8 by 20 feet have been synthetic-bonded



(Courtesy of The Resinous Products & Chemical Co.
Photograph by the Gunnison Housing Corp.)

Figure 6. Preparing layup of veneers for hot press.

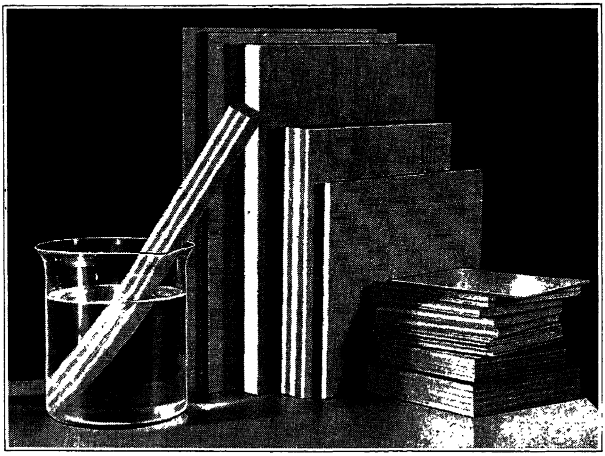


(Courtesy of The Resinous Products and Chemical Co.)

Figure 7. Inserting plywood assembly, with "Tego" interleaved, in hot press.

and used for the exterior and interior walls of dwelling houses. The "Tego"-bonded test panels in Figure 8 illustrate the completely waterproof bond which results from the hot pressing of plywood with this phenol-formaldehyde, film type adhesive.

Many uses have been outlined on previous pages for plastics in the automotive and aircraft fields. Now these materials are used not only for accessories and mechanical parts but are used for structural members and body parts (see Figure 19). Automobile tires have been



(Courtesy of The Resinous Products & Chemical Co.)

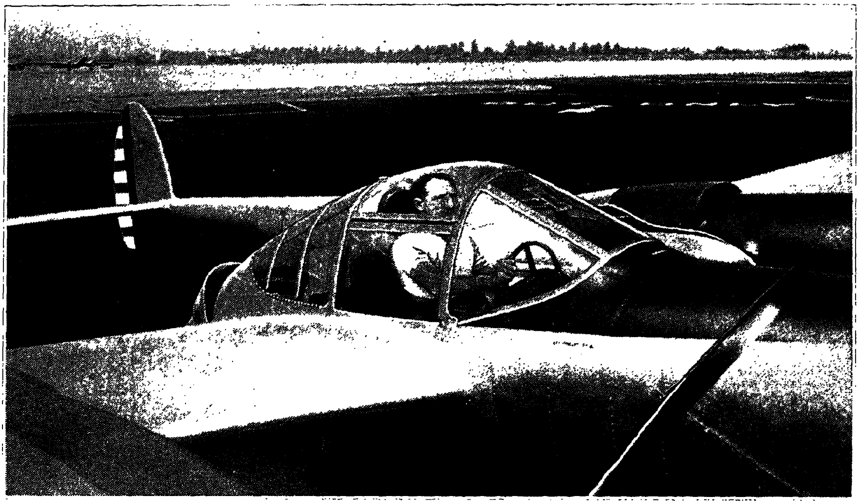
Figure 8. "Tego"-bonded test panels.

made successfully from synthetic rubber. Germany has used "Buna S" for light truck and passenger car tires, but has met some difficulty with it for use in heavy truck tires.

For a few years resinoid adhesives have aided the aircraft industry by providing the bonding material for plywood parts. More recently, however, thin layers of wood have been impregnated with resinoid and the laminations molded around a form to produce the fuselage of an aeroplane. With the advent of flying at high altitudes and at the breath-taking speeds of today's dive bombers, it has been necessary to secure a transparent enclosure for pilots and gunners. "Plexiglas," an acrylic resinoid, has risen to the occasion as is indi-

cated on the Lockheed P-38 in Figure 9 and on the Martin B-26 in Figure 15.

Plastics have found places in the fields of furniture and household accessories manufacture. With some of the qualities of glass and yet with greater durability, transparent acrylates have been adapted to



(Courtesy of Röhm and Haas Co., Inc.)

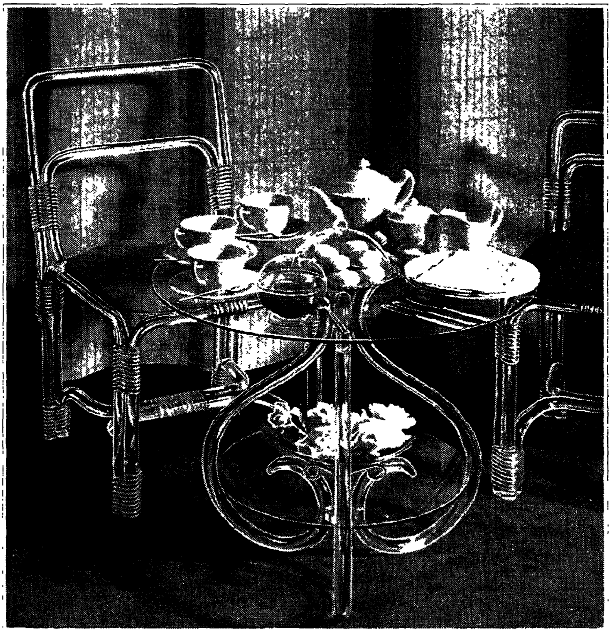
Figure 9. "Plexiglas" nose section of the Lockheed P-38. (Released for publication by the Chief of the Air Corps, May 29, 1941.)

furniture manufacture. Laminated veneers have been used for covering cheaper wood structures to produce a permanent, waterproofed wear and scratch resistant, and even heatproofed surface on tables, chests, and the like. Elastic plastics sheets have been cut into strips and interlaced to form comfortable modern furniture (see Figure 17). The "Vinylite" will stretch when pressure is applied, then spring back *slowly* to the original shape as soon as pressure is released.

PLASTICS OF THE FUTURE

Growth is evident in the plastics industry from many angles. A glance at the volume of production will give one side of the picture; examination of the expanding patent list in the field will give another,

and a study of the models in a competition [4] conducted by the *Modern Plastics* magazine will give a still different concept. Some twenty-five new patents for some phase of plastics are published monthly. An examination of a current issue of this magazine reveals such new materials as: cigarette cases with embossed plastics tops, loop antenna



(Courtesy of the E. I. du Pont de Nemours & Company, Inc.)

Figure 10. Modern furniture molded from "Lucite."

housing, fluorescent tube coils, transparent carved trim, insecticide spray housing, and multiple-cavity molded teeth.

Today our country is ready for plastics development. There is a need for the conservation of all materials. Plastics make possible the use of many otherwise waste products. Just now, when metal must be conserved for war uses, plastics will take the place of metals in

[4] An annual competition conducted by *Modern Plastics* magazine, a monthly publication of the Breskin Publishing Co., 122 E. 42nd St., New York City.

many commercial products. Synthetic rubber will be developed still further. A recent announcement concerns the discovery of a process of making synthetic rubber from dandelions.

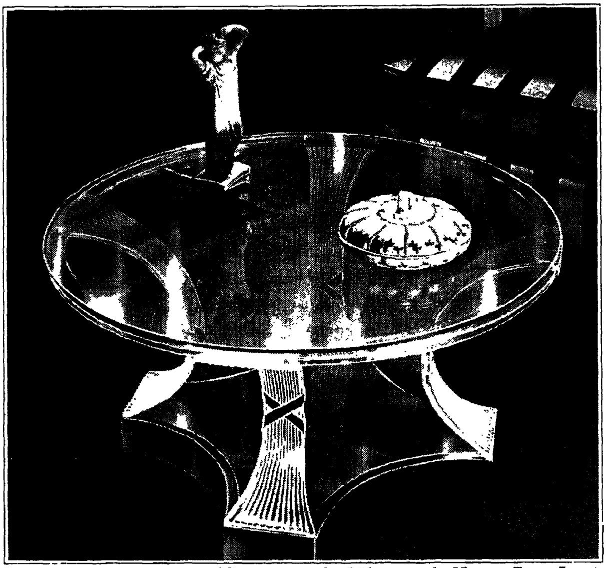
A shortage of zinc and brass has resulted in the development of an extruded strip of cellulose acetate plastics attached to a galvanized iron ribbon for use as a separator in terrazzo floors. War-time housing demands have made possible the manufacturing process which produces continuous fabric-covered, resin-bonded plywood 8 feet wide and over 100 feet long. This is only part of a prefabrication process which enables men to erect a 5-room dwelling with 12 man-hours of labor. Wall sections have both interior and exterior surfaces bonded to the studs to make a one-piece structure.

There may be developed tomorrow or next year the beginnings of a plastics which possesses a surface hardness that is equivalent to that of steel or glass—long a dream of plastics engineers. No one can predict accurately the future of plastics. Some of the outstanding newer uses for plastics mentioned in this chapter, however, may indicate the trend.

Chapter 2

Kinds of Plastics

SOME TWENTY-ODD DISTINCT TYPES OF PLASTICS COMPOUNDS are in production in the United States today. Several of these compounds may be labeled as minor varieties in terms of volume of production. Patents for new types of plastics or for new variations of old plastics are announced monthly, but many of them are destined



(*Courtesy of Röhm and Haas Co., Inc.*)

Figure 11. "Plexiglas" pedestal for coffee table.

never to be discussed outside of a laboratory. Nevertheless it is possible that one of them will one day replace several of our now common plastics, because it possesses one particular quality which is not present in the others and for which chemists have been searching for years. Another plastics may be developed with properties identical with those of a type already in production but with a price 50 per

cent lower. It would have a good chance of displacing the older type. A shortage of coal would certainly disrupt production of phenolic resinoids. A shortage of rubber may, on the other hand, stimulate the production of synthetic rubber to the point where it will approximate in price the natural product.

There are many resinous materials which are "capable of being formed or molded" at some stage or in all stages of their development. Many of these substances may be found in nature; others are produced synthetically. The plastic compounds are here divided into two groups for purposes of discussion: (1) natural resins and (2) artificial resinoids. It should be noted at this point that the natural resins are not *true plastics* by definition, but many of them bear a close relationship to the plastics industry. The synthetic resinous substances are referred to as *resinoids.*

A. NATURAL RESINS
- 1. *Thermoplastic*
  - *a.* Colopony (rosin)
  - *b.* Lac (shellac)
  - *c.* Rubber latex
  - *d.* Amber
  - *e.* Copals
    - (1) Dammar
    - (2) Kauri
  - *f.* Bitumens
    - (1) Asphalt
    - (2) Mineral pitch
  - *g.* Gelatine
  - *h.* Glue
  - *i.* Waxes.
    - (1) Beeswax
    - (2) Caranuba
    - (3) Paraffin
    - (4) Mantan

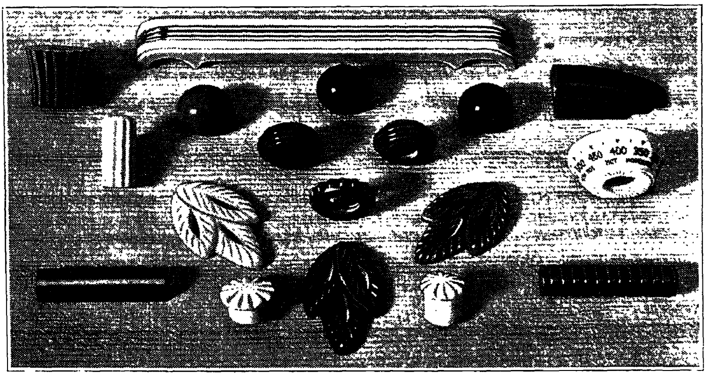
B. ARTIFICIAL RESINOIDS
- 1. *Thermoplastic*
  - *a.* Cellulose derivatives
    - (1) Cellulose acetate
    - (2) Cellulose acetate butyrate
    - (3) Cellulose nitrate
    - (4) Ethylcellulose
  - *b.* Acrylates
  - *c.* Coumarone-indene
  - *d.* Styrenes
  - *e.* Vinyl
  - *f.* Lignin
  - *g.* Protein plastics
    - (1) Soy bean
    - (2) Casein
    - (3) Zein
- 2. *Thermosetting*
  - *a.* Phenol-formaldehyde
  - *b.* Phenol-furfural
  - *c.* Urea-formaldehyde

NATURAL RESINS

This group of resinous materials includes all of those found in nature. It is often necessary for man to perform numerous operations when separating them from the substances in which or with which

they are found and in purifying them for use. Kauri gum, for example, is found buried in the sand as it exuded years ago from a certain species of pine. It has to be dug up and purified before it can be used in varnishes.

The natural resins may be grouped with reference to their origin; animal, vegetable, or mineral. Lac, from which shellac is secured, is produced by a tiny insect which eats the sap from a tree, expels the resinous material, and becomes encrusted in it. Glue, beeswax, and gelatine are animal resins. Those of vegetable origin may be obtained from living plants as are colopony, caranuba wax, and rubber latex, or from fossilized plants as are amber and the copals. Those of mineral origin are the bitumens and paraffin wax.



(Courtesy of the Consolidated Molded Products Corp.)

Figure 12. Typical molded articles produced by a custom molder.

Shellac.—One natural resin, shellac, is similar in many respects to the synthetic products. Prior to the advent of the phonograph industry in 1877, shellac was used in this country mainly for wood finishes. By 1890, shellac was used for flat phonograph records. From that time, it began to be compounded with various inorganic fillers, fibrous substances, and other modifying agents. New uses are being found for this natural product (85-90), "even though it was known and used prior to the Christian Era." With the exception of rosin and the copals, shellac ranks highest in world production (49-42)

of natural organic resins. Its production in 1935 is listed at 32,000 tons as compared with an estimated world production of synthetic resinoids of 120,000 tons during the same year.

Bitumens.—Another natural resin to achieve industrial importance in the plastics industry is the bituminous type. This is commonly identified by the term *cold-molded.* Its development arose from a demand for electric insulators (other than porcelain) and for heat-resistant parts. Bitumen plastics came into use about 1910, and a decade and a half later they exceeded in quantity production the hot-molded phenolics. In recent years, however, the volume of production has been reduced some 75 per cent below that of peak production due to competition from superior synthetic materials.

ARTIFICIAL RESINOIDS

As contrasted with the natural resins, the artificial resinous materials are not *found*; they are *made*. They are compounds which are produced by chemical combinations of other compounds and are the result of chemical reactions. In order to distinguish them from natural resins, the term "resinoid" is applied to them. This term will be used hereafter to designate any synthetic resinous substance.

The manufacture of synthetic products is quite often an expensive process; this is true of resinoids. Certain of these substances have sold for prices as high as thirty-five dollars per pound. Because of a lack of capital or a lack of adaptability of the resinoid, many patents have not resulted in commercial development. Synthetic resinoids are available in a variety of forms. All of these materials may be divided into two groups according to their reaction to an application of heat.

Thermoplastics.—The thermoplastic group is much older than the thermosetting resinoids. Members of the group exist as solids only within certain ranges of temperature. When heat is applied, the resinoid softens and will flow again if the temperature rises high enough. The upper limit of temperature for the solid state ranges from 110 degrees to 200 degrees Fahrenheit. This property which permits the resinous substances to flow at the higher temperatures, even after they are once formed, saves raw materials, since seconds and scraps may be reformed by the application of heat.

Cellulose Derivatives.—The largest division of thermoplastic resinoids is made up of the cellulose derivatives. The value of raw materials which went into producing two types, cellulose acetate and cellulose nitrate plastics, made up some 45 per cent of the *total* volume of all raw materials for plastics production in the year 1939. Cellulose obtained from cotton and wood pulp provided the background material for these plastics. Wood pulp, when used alone and treated differently, is used in the production of rayon. Cellulose acetate butyrate and ethylcellulose molding powder are also members of the group.

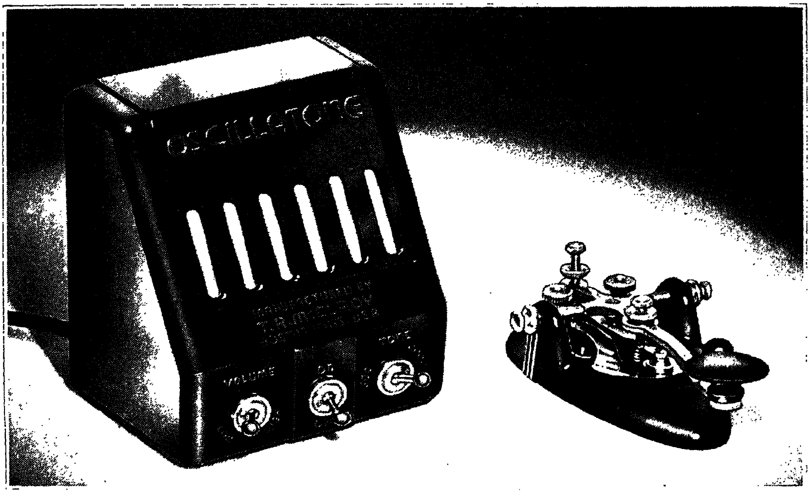
The oldest of the synthetic plastics is a thermoplastic, *cellulose nitrate.* This compound is important in three large fields of application; plastics, protective coatings, and explosives. Their essential difference depends upon the nitrogen content. For plastics use, the content varies from 10.5 to 11.5 per cent. Lacquers use approximately 12 per cent and explosives approach 13 per cent of nitrogen content.

Cellulose-nitrate plastics, also called pyroxylin, may be fabricated by almost any means. Since it is unstable in the presence of heat, however, it is not suited for injection molding. A wide range of color is possible—even the transparent colors can be produced. It is outstanding for its resistance to water and for its toughness. Because it is soluble in certain solvents, it is easily cemented. An outstanding weakness is inflammability. Drafting instruments, fountain pens, combs, shoe-heel coverings, and spectacle frames are typical applications of this plastics. Cellulose nitrate is mixed with wood flour to produce plastic wood. These and other ingredients are dissolved in acetone, which vaporizes upon contact with the air, leaving the resinoid to set. Common trade names include: "Celluloid," "Pyralin," "Nixonoid," "Monsanto Cellulose Nitrate," and "Amerith."

Cellulose-acetate plastics are produced by treating cotton linters with acetic acid in the presence of sulphuric acid as a catalyst. The fact that acetate plastics will not support combustion makes them definitely superior to their nitrate relative. Because of toughness and high mechanical strength, articles may be molded with thin cross-sections. Transparent, translucent, and all shades of color are available. All forms of molding compounds and sheets are manufactured.

Liquid solder is made from powdered aluminum combined with a cellulose binder and a volatile solvent.

Fabricating may be done by most of the mechanical operations. Because it is soluble, acetate plastics can be cemented readily. Typical applications include automobile steering wheels and appointments, lamp shades and accessories, fishing lines and reels, and toilet articles. "Nixonite," "Plastacele," "Tenite I," "Lumarith," "Bakelite C. A.," and "Monsanto C. A." are common trade names.



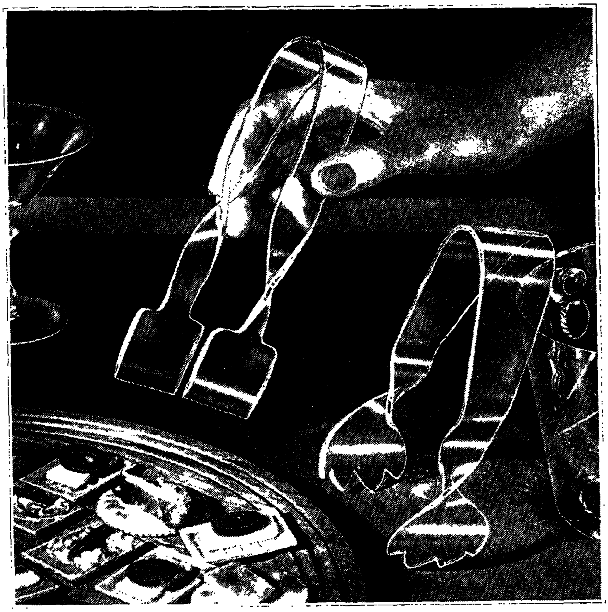
(Courtesy of Monsanto Chemical Co.)

Figure 13. McElroy oscillatone molded of cellulose acetate.

Cellulose acetate butyrate plastics are made in much the same manner as the cellulose acetate types except that butyric acids and anhydrides are added to the acetic acid. Less pressure is required in molding, and a somewhat clearly defined melting point may be obtained. The molding compounds available may be molded by injection, compression, and continuous extrusion.

Continuous extrusions have been fabricated into woven strips and reeds for outdoor furniture. The weather-resisting qualities make possible this interesting application. Gunstocks, refrigerator parts, radio cases, and brush handles are other uses of the plastics. "Tenite II" stands alone as a representative of the cellulose acetate butyrate plastics.

In the production of *ethylcellulose,* cotton linters are treated with sodium hydroxide. The resulting alkali cellulose is treated with ethyl chloride or sulfate. Because of its low-temperature flexibility, ethylcellulose may be used as extruded strips for modern types of furniture. Cloth coatings, extension wire insulation, and protective coatings are typical uses. "Dow Ethocel," "Dow Ethofoil," and "Hercules Ethylcellulose" are the new trade names in the field.



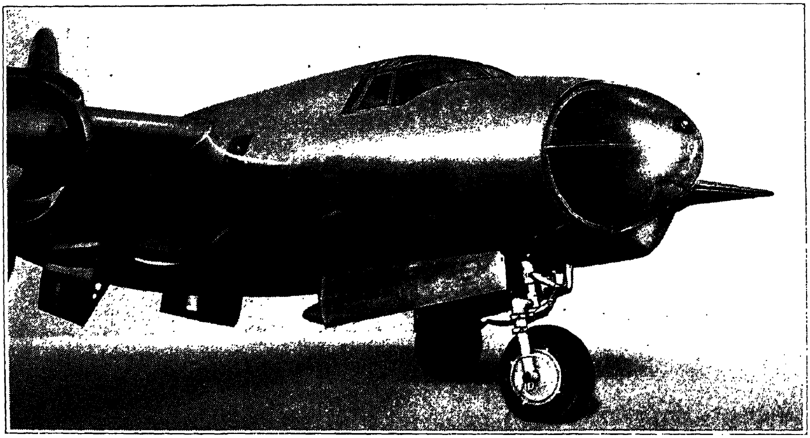
(Courtesy of Röhm and Haas Co., Inc.)

Figure 14. Ice tongs fabricated from "Plexiglas" by Creative Plastics.

Acrylates.—Among the oldest plastics and yet among those achieving recent industrial importance is the group which is classed as *acrylates.* Of all the plastics, this group claims superiority in the field of optics. It is because of this quality that the acrylic plastics are enjoying such rapid growth at the present time. Four years ago, they were practically unknown in the automobile industry. Today they

are used extensively in the automotive field as well as in the aviation industry. A demand for transparent enclosures on aircraft and other machines will no doubt increase demands for the acrylic plastics in industry. The bomber shown in Figure 15 is equipped throughout with acrylic resinoid parts.

Coumarone-Indene.—The coumarone-indene resinoids were among the first synthetic plastics developed to a stage of commercial importance in the United States. They were discovered as early as 1890 when Kraemer and Spilker succeeded in polymerizing coumarone and indene which had been isolated from coal tar. Commercial development was made possible by the stimulus of World War I.



(Courtesy of Röhm and Haas Co., Inc.)

Figure 15. Martin B-26 medium bomber, showing "Plexiglas" nose section.

The importance of these resinoids arises from their compatibility with other plastics. They may be combined with other materials to produce new substances with physical properties different from the parent compounds. A careful survey (46-92) reveals that the following materials may be blended with the coumarone-indene resinoids: Some ten kinds of waxes; eleven kinds of natural resins and their derivatives; synthetic resinoids including certain alkyds, methacrylates, phenolics, polystyrene, and vinyl; some nine forms of rubber;

and several of the bitumens. When phenolic materials are used in the polymerization process, the coumarone-indene resinoids may blend with urea-formaldehyde, shellac nitro-cellulose, and cellulose acetate resinoids.

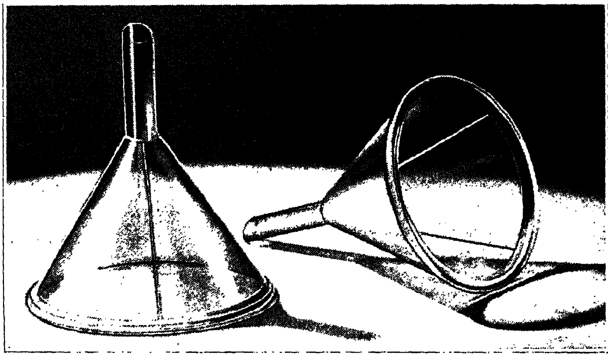
Applications for these materials are found in the electrical and automotive industries in the form of plugs, toggles, cable coverings, and switch parts which are exposed to weather conditions. Another application is found in the manufacture of light-colored mastic floor tile. This type of flooring may be quickly laid in attractive shades and marbleized effects and will resist attacks of strong soaps and acids. Other applications may be found: in the manufacture of transcription records from vinyl resinoid where coumarone-indene resinoids furnish the flux, in impregnating paper, and in the manufacture of protective coatings.

Development of the coumarone-indene plastics has achieved greater proportions in Germany than in any other country. Simonds (72-67) states that there are "more than thirty varieties of indene resins sold in Germany today." Common trade names in the United States are *Cumar* and *Nevindene*.

Styrenes.—Polystyrene, which is obtained by polymerizing styrene, has been known to science for over one hundred years, but it has acquired economic significance in the United States only during the past four years. Its development lagged behind that of other plastics because of inadequate manufacturing methods and resultant high cost.

Styrene is prepared by separating hydrogen from ethyl benzene obtained from natural sources or produced synthetically from ethyl chloride and benzine. Polystyrene is superior, it is claimed, to all other known molded plastics in its dielectric (non-conducting) properties. Because it is a thermoplastic, injection molding is the most economical method of production. The specific gravity is only 1.07, and the sprues and runners may be cut and remolded. Since it is originally a colorless liquid, it is possible through the use of dyes and pigments, to produce all colors, pastel shades, degrees of transparency, and variegated effects.

One of the early uses of polystyrene was for dental plates. Demands from the radio and television industries have given impetus to the the production of these plastics. Since it can be readily machined, costume jewelry is demanding considerable quantities of the material. Because of its acid resistance, its transparency, and its tasteless and odorless properties, polystyrene is used for strong alkali and hydrofluoric acid containers, for liquor dispensers and bar accessories, for packaging of cosmetics, for food containers and refrigerator trim, and a variety of closures. Because it will carry light around curved sections, it is in demand for instrument panels and illuminated signs to give light without glare.



(Courtesy of The Monsanto Chemical Co.)

Figure 16. Funnels molded of polystyrene.

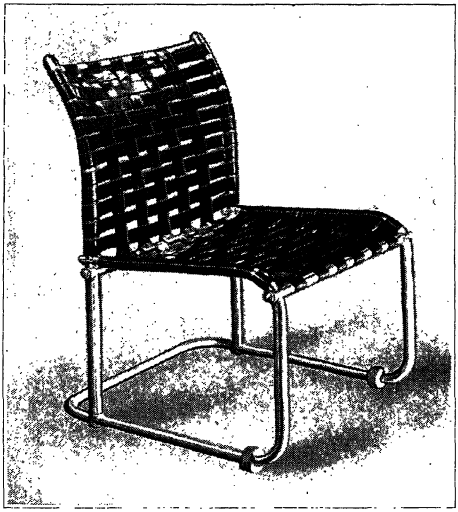
One handicap to the development of polystyrene is its relatively high cost. In this country, the cost is approximately twice that in Germany, where it has been used extensively for many years. A recent development uses a thin sheet (1 mil, or .001 inch) between metallic foils on a low-capacitance condenser for use in the radio and television fields. Saxophone reeds, diathermizers, and vest-pocket pencil magnifiers are other new articles molded from polystyrene.

Three manufacturers have identified themselves with these plastics. The Dow Chemical Company calls its product, "Styron," the Bakelite Corporation produces "Bakelite Polystyrene," and the Monsanto Chemical Company manufacturers "Monsanto Polystyrene."

Vinyl.—Organic plastics under this heading have been known in chemical laboratories for over a century and in industry for a brief period of ten years. The volume of industrial production has so increased that the vinyl resinoids are now available at a fraction of their former cost.

The development of vinyl resinoids has been due largely to the efforts of the Carbide and Carbon Chemicals Corporation. This organization has developed four series of resinoids as follows:

1. *Series A*—vinyl acetate (polymerized)—adhesives, molding compounds.



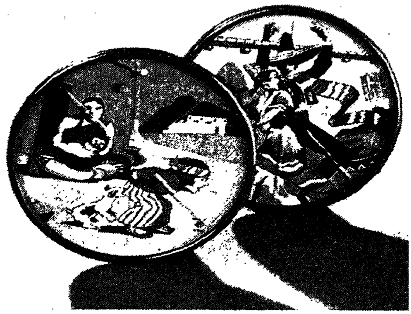
(Courtesy of Carbide and Carbon Chemicals Corp.)

Figure 17. Modern metal chair with seat and back woven from strips of flexible "Vinylite" plastics.

2. *Series Q*—vinyl chloride (polymerized)—flexible surface coatings and non-corrosive coatings.
3. *Series V*—vinyl acetate and vinyl chloride (copolymer)—calendered sheeting and fibers.
4. *Series X*—aldehyde reaction products—experimental stage.

These series have been developed under the trade names: "Vinylite," "Vinylseal," "Vinyon" (fiber), and "Koroseal."

Vinyl acetate is a colorless, odorless, tasteless, non-toxic, and slow-burning thermoplastic. *Vinyl chloride* is a clear, odorless, tasteless, non-toxic, non-burning, and chemical-resistant thermoplastic with low water-absorption properties. Copolymerized vinyl chloride and vinyl acetate combines the desirable properties of the foregoing types to produce an odorless, tasteless, non-toxic, non-inflammable, non-shrinking, non-warping solid with excellent resistance to water absorption, chemicals, and current flow.

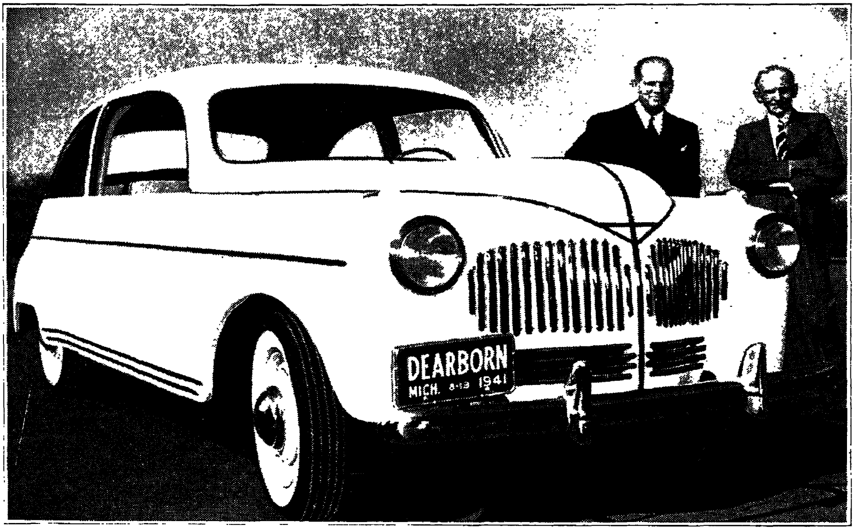


(Courtesy of Carbide and Carbon Chemicals Corp.)

Figure 18. Metal coasters protected with coatings of "Vinylite" resinoid applied from solution before the metal is blanked, embossed, and crimped.

Vinyl acetate is available as molding powder and in liquid solutions which are used for plastic wood, inks, and surface coatings. Vinyl chloride is available as molding powder and in the form of sheets and extrusions used in the production of covering for flexible cables, tank linings, coated fabrics, and flexible tubes. The copolymer of the foregoing compounds is available in all forms of molding compounds, solid rods, tubes, coated papers, calendered sheets and film, and thin plasticized film. They have been used to produce belts, garters, braces, watch straps, and key chains; plastics bindings, pen parts, electrical tapes, and drafting instruments; rain coats, shoe uppers, and transparent packaging; and sound recording discs, films, radio parts, and combs.

Lignin Plastics.—The lignin plastics are not to be confused with cellulose derivatives. Cellulose is the fibrous portion of wood and comprises about 50 per cent of the woody substance. Lignin is the binder which holds together the other materials in wood and comprises about 30 per cent of the woody substance. It is a by-product of the manufacture of paper and cellulose derivatives. Lignin, in a manner which does not destroy it and which activates it so that its binding power can be used again, is released by high-pressure steam.



(Courtesy of the Ford Motor Co.)

Figure 19. Plastics automobile body.

The fibers are then formed into mats, on a paper machine, several sheets of which are assembled for pressing into a final laminated sheet. When about one hundred and fifty sheets are stacked, pressed, and cured, a slab one inch in thickness is obtained.

Lignin plastics are limited to brown and black colors. Sheets and rods are available for machining like any other form of laminated plastics. In a recently installed press at the Masonite Corporation, sheets 4′x12′ may be cured. Uncured sheets are called by the trade name "Benaloid," and the cured sheets by the name "Benalite."

Protein Plastics.—Protein plastics are derived directly from plant and animal products. They are mixed with plasticizers and formed into sheets, rods, and tubes. Hardening is accomplished by a special treatment with formaldehyde. Common protein plastics are derived from soy beans, casein (milk), and zein (corn).

The term *soy-bean plastics* usually means filler combined with phenolic molding powder. Soy-bean plastics have been promoted by the Ford Motor Company for a number of years. Numerous automobile parts, such as steering wheels, distributor caps and electric parts, and a variety of knobs, have entered the industrial picture as examples of molded parts produced from soy beans. Experiments which may lead to an automobile body made completely from laminated plastics are under way.

Zein plastics has been produced from corn. As yet it is in its experimental stages. It has been estimated that the growth of this plastics to industrial importance would increase the price of corn by 50 to 60 cents per bushel. Its high cost, 20 to 25 cents per pound, and its yellow color have prohibited further development. Coffee beans and peanuts also have yielded materials which have been used as the resinous binder necessary for certain types of plastics.

Just a little over a decade ago, *casein* ranked as one of our most important plastics. The history of casein plastics dates from 1890 when one Dr. Adolph Spitteler from Hamburg, Germany, sought to produce a "white blackboard" for use in a classroom. Sour milk and formaldehyde were mixed and casein plastics was born.

The original plastics was horn-like in appearance and texture. It has been used for many a button and buckle through the past few decades. Casein plastics was a commercial development in Europe as early as 1904. The curing of casein plastics requires considerable time, especially for the thicker pieces. Casein is excluded from the molded plastics trade, because the rate of curing thick parts and thin parts is unequal. Casein compositions are hygroscopic, and plastics of this type are not waterproof under ordinary conditions. There is a tendency for sheets to warp because of unequal absorption of moisture. The use of casein is, therefore, somewhat limited by this inherent weakness.

Originally the colors of casein plastics were made to imitate horn, but many beautiful colors have been added within recent years. Use of casein in the United States is, in general, limited to the button, buckle, slide, and other accessories trades—uses to which it is well adapted.

THERMOSETTING RESINOIDS.—In the original state, the thermosetting group of resinoids exist as thermoplastics. Catalysts are added and heat is applied. Polymerization takes place at the higher temperatures. The plastics is said to "set" in a manner similar to concrete. Thus water

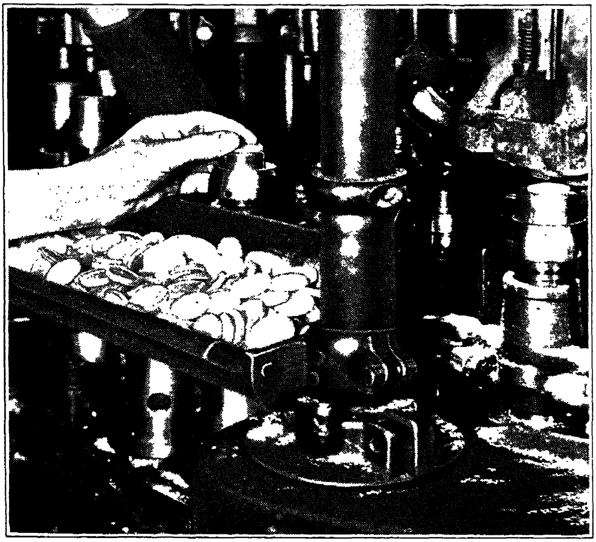


Figure 20. Machining buttons from cast resinoid.

is added to cement and it sets so that water thereafter has little effect upon it. Similarly heat is applied to unpolymerized plastics material and it sets by chemical action so that heat does not affect it when applied later.

All of the thermosetting plastics may be made more flexible or less rigid by an application of heat, but they will not flow as will the thermoplastics. This property permits them to be adapted to uses involving considerable heat—uses which are impossible for the other group of materials.

Phenol-Formaldehyde.—Perhaps the best known group of the thermosetting resinoids is that known as the *phenolics.* Even though phenolic plastics may be obtained by the interaction of many different phenols with other materials, the phenol-formaldehyde resinoid is the most important example of the phenolic group. Two common antiseptics, phenol (carbolic acid) and formaldehyde, unite to produce a substance entirely different from either material.

The development of phenolics has continued since the early part of this century when Dr. Leo H. Baekeland and others became interested in these compounds. Much chemical research has been done and many patents have been secured in order to reach the present state of perfection. For a long period of time an inherent weakness of these plastics arose from the difficulty of producing a light, colorfast material.

Color was limited to the blacks and browns. Much of this difficulty has been overcome, and the phenolics are now available in a wide variety of colors from light shades to jet black.

Phenol-formaldehyde plastics are noted for their versatility. They are available as molding compounds, cast resinoids, and laminated materials. Because they can be combined with so many different kinds of fillers and other kinds of resinoids, these compounds may be adapted to almost any requirement. They can be given almost any degree of heat resistance or surface hardness by varying the type of filler and degree of curing, respectively.

To assist the reader in obtaining the picture of phenol-formaldehyde plastics, it may be helpful to list a *few* of the trade names—other trade names will be found in Appendix A.

Molded: "Bakelite," "Durez," "Resinox," and "Textolite."

Cast: "Bakelite," "Catalin," "Monsanto," and "Marblette."

Laminated: "Textolite," "Formica," "Lamicord," and "Micarta."

These resinoids are used in a wide variety of ways, from molding tiny insulator parts to large housings for counter scales; from casting tiny costume jewelry parts to large radio cabinets; and from laminating tiny aviation parts to large panels 4x12 feet. Production of phenol-formaldehyde plastics enjoys the greatest volume of any single plastics type.

Phenol-Furfural.—The word *furfural* is derived from two Latin words: *furfur*, meaning bran or scale, and alium, meaning oil. One might suspect that furfural is obtained from woody plant fibers. Common sources for the material are oat husks, wheat hulls, straw, bagasse, corn stalks, rice hulls, cotton seed husks, corn cobs, kapok, and sunflower seed husks. The furfural is obtained by digesting one of these materials (which contain pentosan) with an acid such as sulphuric or hydrochloric at 145 degrees C under pressure and distilling off the desired material. Phenol is, of course, obtained as a by-product of coke manufacture.

About twenty years ago the first commercial resinoid made from phenol-furfural was produced. At that time the cost of the material was prohibitive. Chemical research, however, has borne fruit and the cost has been reduced to 9 cents per pound. Simonds (72-73) sets the world production of furfural in 1940 at approximately 35,000 tons.

The furfural plastics are available in liquid form to be used in surface coatings and as molding compounds. Because of certain *flow* properties this thermosetting material may be used in injection molding processes. The resinoid does not begin to set into a leathery or rubber-like mass which will not flow into mold cavities, as does the phenol-formaldehyde type when high temperatures are established for a short period of time. The resinoid will actually retain its fluid state for as long as forty-five minutes under molding conditions. This property makes possible its use in difficult cavity molds. Another characteristic which gives the furfural plastics a great advantage is its freedom from scorching under high molding temperatures; resulting in shorter curing periods and fewer rejections than is possible with many kinds of phenol-formaldehyde molding compounds.

Phenol-furfural plastics are produced under the trade name "Durite." Typical uses for these plastics include aircraft pulleys, bonding material used in abrasive wheel manufacture, distributor heads, electrical parts, heating appliance handles and housings, and photo-developing equipment where dark colors are permitted. Aside from the specific superiorities of the plastics, these materials should interest the average citizen, who is becoming increasingly *conserva-*

tion conscious, because here is an opportunity to utilize what would otherwise be waste materials.

Urea-Formaldehyde.—The urea-formaldehyde plastics developed from attempts to secure colors lighter than were possible with the phenolics. They were produced commercially in this country in 1928. Since that time, they have become one of our rapidly growing plastics. Urea is obtained synthetically from ammonia and carbon dioxide, and formaldehyde is obtained from hydrogen and carbon monoxide. The urea is reacted with formaldehyde to produce the desired resinoid.

Urea resinoids compare quite favorably with the phenolics in all molding characteristics. Their higher cost is partially offset by the fact that they are water-clear, thus making possible bright colors and pastel shades. Transparent or translucent parts are common and the tendency is for a surface finish to improve through handling rather than become dull.

Urea resinoids are available in a variety of forms, so that wide application is possible. A liquid form treats paper, cloth, and wood for laminating and veneering. Another liquid form treats textiles to make them water-repellent, crush-proof, and wear-resistant. Heat-setting adhesives and cold-setting cements are available. Molding compounds are used to produce such articles as closures, tablesware, electrical parts and fixtures, and household-appliance housings. These plastics are used extensively in fluorescent fixtures. Another form of the plastics is used in preparing surface coatings.

The urea plastics are manufactured under the trade name: "Bakelite Urea," "Plaskon," and "Beetle." The chief development in a recent year in urea-formaldehyde plastics occurs in the plywood and aviation industries, where improved adhesives have been developed.

BORDERLINE MATERIALS

This book is concerned primarily with the new synthetic solids in the form of sheets, rods, and tubes, special castings, and molding compounds which may be used to produce objects of utilitarian and decorative value. There are, however, many synthetic materials which are derived from the same or similar resinoids mentioned heretofore

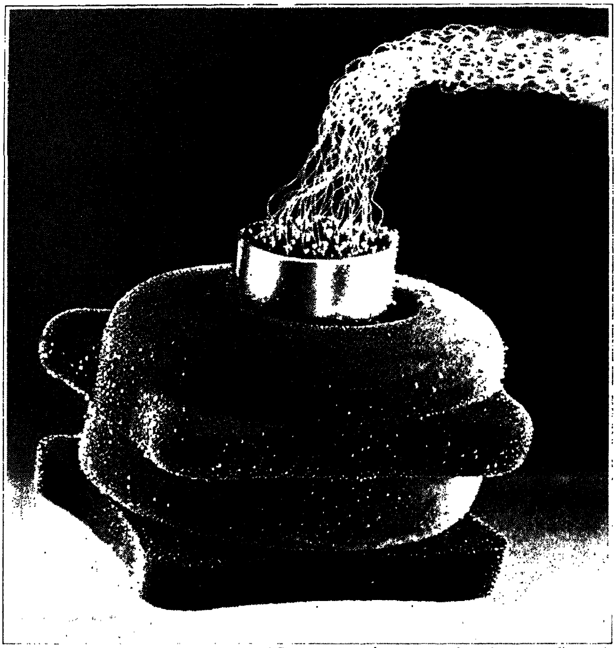
which arouse considerable curiosity and which require explanation. It is the purpose to mention briefly a few of the more common of these "borderline materials" and give the reader some notion of their uses.

Synthetic Fibers.—There is a variety of synthetic fibers which are in use today, but those which have achieved commercial importance are the following: "Nylon," "Vinyon," cellulose acetate rayon, viscose rayon, and protein fibers. These synthetic materials may be fabricated into yarn used for the cloth in an evening gown, brush bristles, cords and sutures, sheets, and filters.

"Nylon," is a term which applies, not to fibers or bristles, but to the synthetic compounds which may be used for fabricating textile fibers, bristles, and sheets. While the compound is similar to silk, wool, and hair, it is dissimilar (chemically) to any known natural product.

Single strands of "Nylon" may be wet with water, but the water absorption is low as compared with natural yarns. The material will melt at a temperature ranging from 200 to 600 degrees F., depending upon the composition. All fibers are resistant to soap and dry cleaning fluids, and may be set to shape while in contact with hot water and steam. These properties make the yarn especially adaptable to the manufacture of hosiery. Such applications as fishing leaders, bead cord, shoe laces, knitted and woven fabrics, thread, brush bristles, musical instrument strings, tennis racket strings, and electrical insulation are typical uses for "Nylon."

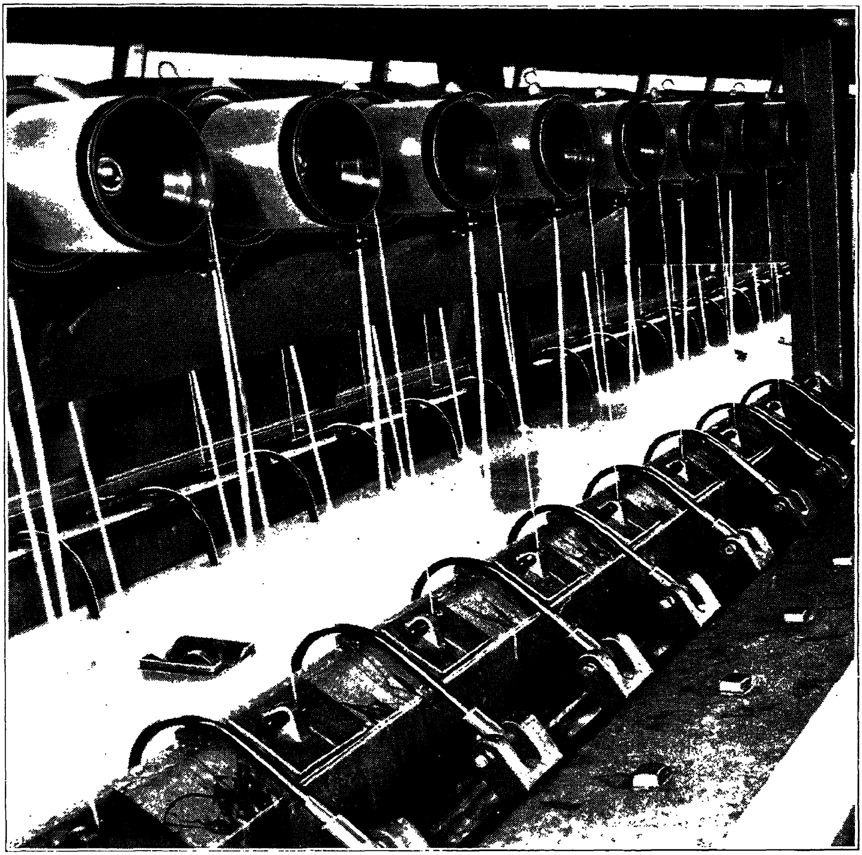
"Vinyon" is a synthetic fiber produced from an unplasticized copolymer of vinyl acetate and vinyl chloride, by the Carbide and Carbon Chemicals Corporation. These fibers are water-repellent, and surface wetting may be accomplished only by wetting agents. The yarn is thermoplastic and will start to shrink when temperatures exceed 65 degrees C. This property is employed to produce shrink-fit tubing or sheeting. Dyes may be used successfully; and chemical, bacterial and fungus, and electrical resistance are common properties. These synthetic fibers are adapted to the manufacture of garments in the apparel field and of filter fabrics.



(Courtesy of Industrial Rayon Corp.)

Figure 21. Viscose forced through the tiny holes in this platinum spinneret is transformed into filaments when it comes in contact with the spin bath.

Cellulose-acetate rayon is produced from cellulose acetate, which is soluble in acetone. The chemical formation for cellulose-acetate rayon is essentially the same as for cellulose-acetate plastics. Transforming the acetate into fibers is a physical process accomplished by dissolving the material to a viscous solution which is forced down through tiny holes into a rising current of warm air. The warm air vaporizes the solvent (acetone) and leaves continuous filaments which may be wound on spools as they come from the perforated chamber. The size of the filaments may vary from those of silk to those of coarse wool by varying the size of the apparatus in the spinning chambers. Rayon thus processed has low moisture absorption, has resistance to wrinkling and creasing, has excellent draping qualities, a pleasant feel to the skin, and is clear white in color. Dyes which



(Courtesy of Industrial Rayon Corp.)

Figure 22. Rayon is "born" inside the hooded enclosure atop the continuous spinning machines at Painesville, O. Each of these curved tubes is capped by a tiny spinneret with microscopic holes through which the metered flow of viscose enters the coagulating bath.

do not affect other rayon or natural fabrics may be used on acetate rayon.

Viscose rayon is produced by reducing cellulose (from wood pulp) to a liquid which is then spun into filaments of a solid material again. The filaments from the spinneret (see Figure 21) are drawn up on reels to start the continuous processing sequence. Each platinum nozzle

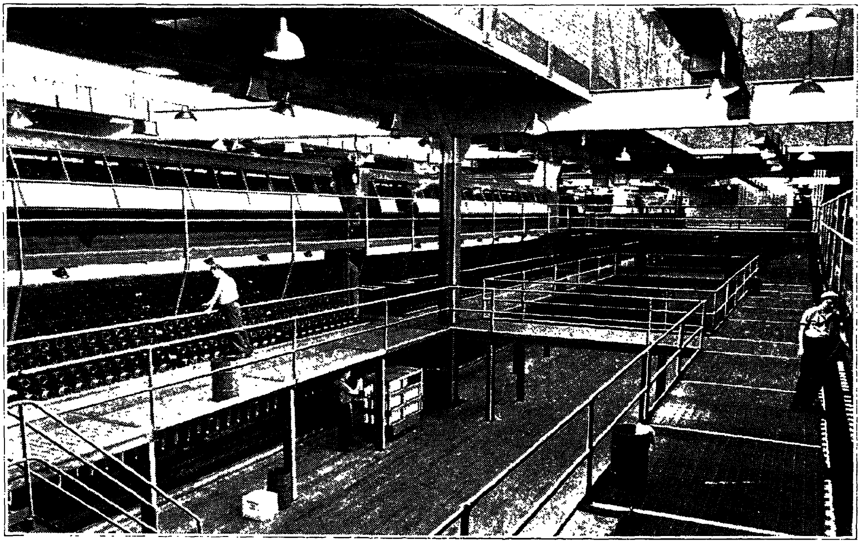
(Courtesy of Industrial Rayon Corp.)

Figure 23. The endless threads of yarn produced at 9600 spinning positions in the Industrial Rayon Corporation plant at Painesville, pass from reel to reel in the processing sequence provided by continuous spinning machines. Each thread is treated individually as it rides on these thread advancing reels of a chemically resistant molded plastics, over which warm corrosive solutions and washes flow continuously.

in a spinneret has from 30 to 90 holes evenly distributed over face one-half inch in diameter. The number of holes determines the number of filaments in each thread of yarn. The plastics guide below the reels in Figure 22 strips thread of excess moisture.

Rayon is washed, bleached, and treated as it passes from step to step over the reels. Washes and treating solutions circulate through channels molded in hard rubber and flow out the reels through bent glass tubes. Continuous threads of yarn up to sixty-eight miles in length and yielding over 2½ pounds are wound on plastics spools.

Protein Fibers are prepared in much the same manner as the protein plastics. Two substances, casein and soy beans, have been used successfully. Experiments with peanut and fish fibers are in progress.



(Courtesy of Industrial Rayon Corp.)

Figure 24. Yarn descends from the spinneret to the terraced banks of thread-advancing plastics reels to the middle section for processing. It is dried, twisted, and wound onto bobbins at the bottom.

Once the protein-base resinoid is produced, it is extruded through tiny holes into an acid bath which hydrolyzes it to a proper degree. The acid coagulates the filaments which are then wound into skeins. These protein fibers have been used alone and in combination with wool. The best general success seems to have come with the latter procedure. The present rate of production of casein fiber has been estimated at 5,000,000 pounds annually.

Synthetic Rubber.—It has been estimated that there are some 32,000 developed uses for natural rubber. Synthetic rubber has been a dream of scientists for more than a century. For the past decade such a synthetic material has enjoyed commercial success. Synthetic rubber is of especial interest to the United States because of the war emergency, since natural rubber must be imported, and because of the wide market for synthetic materials if they can be so developed as to be either cheaper or of superior quality.

More than ten trade names (such as "Thiokol," "Neoprene," "Vistanex," "Koroseal," and "Chemigum") have appeared in this country. There are many others in Russia, Germany, Belgium, England, and Japan. All of these materials possess physical properties similar to those of natural rubber. These synthetic compounds cost approximately twice as much as natural rubber. If they are to be used, therefore, they must be superior in some quality.

Higher costs of the synthetic compounds are offset for many uses by their superiority in contact with petroleum products—natural rubber swells and weakens when in contact with most hydrocarbons. This property is responsible for the following applications for synthetic rubber: hose and tubing for petroleum products, truck tires and casters, aprons, gloves, and tank linings. Tubes and rollers which come in contact with printer's ink and surface coatings are also made of synthetic rubber. The impregnation of fabrics opens up another large field of uses for these synthetic compounds.

Surface Coatings.—The application of synthetic resinous materials to the field of surface coatings has developed during the past decade to a point where large volumes of the materials are consumed annually. Varnishes, lacquers, paints, enamels, and impregnating solutions are made from amino, alkyd, phenolic, and vinyl resinoids and chlorinated rubber. These resinoids are used either alone or in combination with other finishing materials.

Use of synthetic resinoids has resulted in greater flexibility, greater surface hardness, greater wear resistance, greater water and heat resistance, resistance to chemicals, non-inflammability, electrical insulation, greater color selection, better corrosion and weather resistance, and speed in drying. Tank linings for milk, wine, and acids, finishes on truck bodies and other large objects where the finish cannot be baked on, finishes on metal objects which must be formed after finishes are applied, finishes which come in contact with food products, structural steel finish, and finishes on objects in contact with salt water are all superior because of synthetic surface coatings.

Packaging.—Within recent years great strides have been made in the field of packaging. (The term as used here is to be construed to

mean thin film-like, transparent materials, either water clear or colored.) "Cellophane" and other cellulose derivatives have been used to improve the appearance of merchandise and to protect it from soilure. Another packaging material, "Sylphrap," is claimed to exclude ultra-violet light. Foodstuffs wrapped in this material are protected, to an extent, against rancidity.

Chapter 3

Materials, Production, and Application of Plastics

WATER, AIR, AND COAL are materials which are familiar to everyone. Starting with these materials and an abundance of imagination, let us proceed to extract from them certain elements, combine these elements in a reaction kettle with a few acids, apply some heat, then force the mass into a press which has a specially designed cavity. The procedure doesn't sound very interesting, to say the least; but let us examine the results of our efforts. Out of the press comes a glistening opaque white desk-clock case. If you can visualize this procedure, you can appreciate the romance of modern plastics.

The processes sound quite simple—actually they are not as simple as is indicated—but that is the achievement of modern synthetic plastics. A synthetic process has been completed because the clock case bears little relationship to the original materials (water, air, and coal)—a compound has originated from complicated chemical action brought about by the reaction of formaldehyde upon urea. One can't find plastics—he makes them.

A glance at the organization of the plastics industry may assist the reader in understanding the following pages. Figure 25 shows the flow of base materials from the manufacturer to a consumer. These individuals, designer, engineer, and chemist, stand out in the picture. It is the chemist who makes progress for the others possible. Chemistry it is which discovers a best way for combining elements or compounds to produce synthetic plastics. A designer starts to work as soon as a base material is produced. It is he who lays plans for molds and dies which a manufacturer must use. Another designer organizes, graphically, his concept of the finished product. Once these steps have been completed, an engineer determines ways and means for accomplishing the task. How is the necessary amount of heat to be provided?

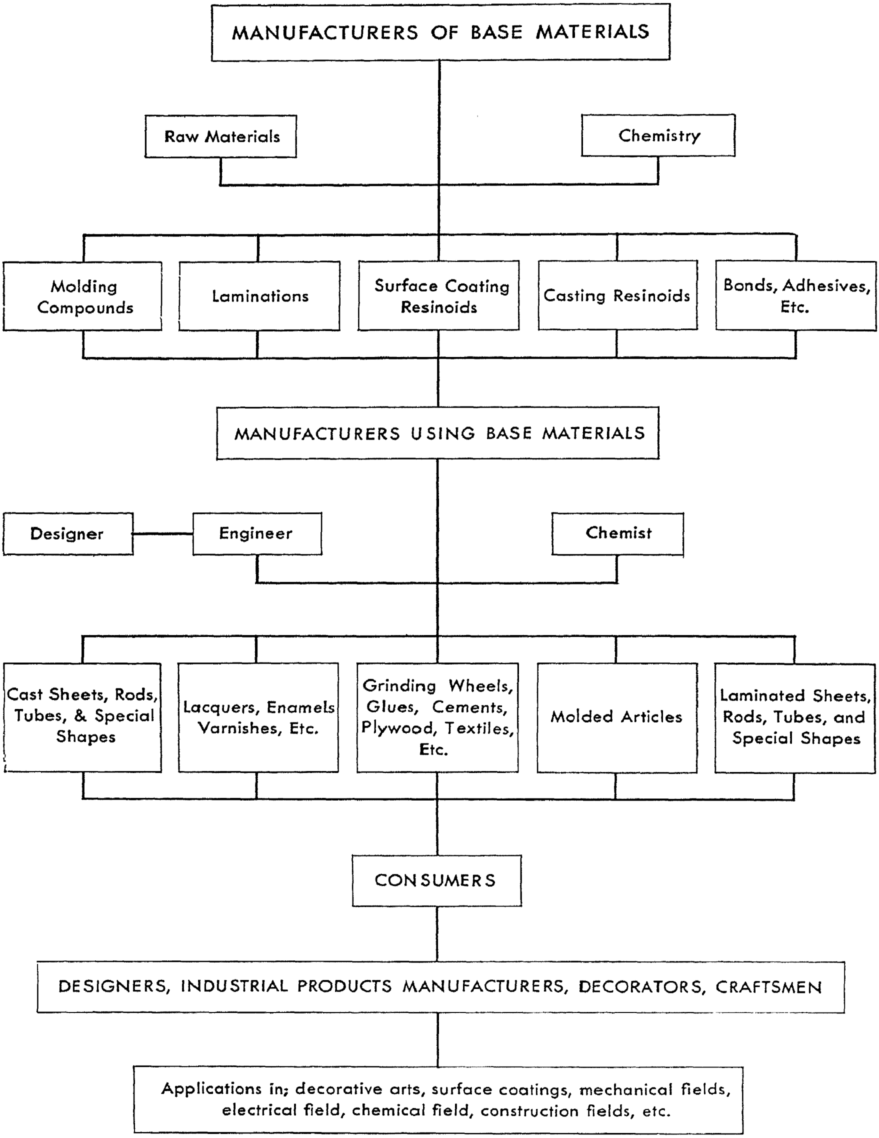


Figure 25. Organization chart of the plastics industry. (23-12.)

How can the completed casting be cured? How can the molding cycle be speeded up? These problems and others must be solved before a consumer can enjoy a beautiful molded article, or a cast shape from which a useful object may be fabricated.

BASIC MATERIALS FOR MANUFACTURE

A culinary artist who sets about the baking of a cake must assemble cartain essential materials for her use. Flour is the *filler*; lard or butter may be the *shortening*; eggs, baking powder, or cream of tartar provides the *leavening*; sugar, salt, and various extracts are necessary for *flavoring*; and milk or water gives the moisture necessary for thorough mixing. In a like manner, a plastics engineer must secure certain basic materials necessary for the manufacture of his synthetic plastics. These materials are classified as follows: binders, fillers, dyes, pigments, lubricants, plasticizers, hardeners, solvents, catalysts, and accelerators.

Binders cement the ingredients of a molding composition together. They may consist of one or more synthetic resinoids. Thermoplastic binders appear in polymerized form and thermo-setting binders appear as unpolymerized or A-stage resinoids. Binders may be used with or without fillers.

Fillers are added to provide desired qualities not possessed by the binder. A general-purpose filler is wood flour. Asbestos provides heat and chemical resistance. Impact resistance is achieved through fibrous textiles. Powdered slate, gypsum, and China clay add hardness. Other fillers used are powdered mica, powdered rubber, pumice, lime, whiting, powdered metals, barytes, silicates, talc, carbon black, emery, paper pulp, corn husks, seed hulls, graphite, bagasse, barium sulphate, calcium sulphate, cement, and kieselguhr.

Dyes should be soluble in the binder, should be light-fast, and should be heat-proof. Anthraquinane and alizarin dyes are used for fast colors.

Pigments are finely ground particles of colored earth or ores and are used to establish the hue of a resinoid.

Lubricants are used with molding compounds. They are necessary to prevent the compound from sticking to the mold and to reduce

internal friction. Lubricants commonly used are stearates, stearic acid, and metallic soaps. Graphite and carnauba wax are sometimes used for breaking in a mold.

Plasticizers are used to improve the plasticity of the material and to modify other physical characteristics. Cellulose acetate can be molded without the use of a plasticizer, but much higher temperature (which often results in discolorization) and higher pressure are required. A few of the plasticizers in common use are camphor, castor oil, dibutyl tartrate, dimethyl phthalate, and triacetin.

Hardeners are essential as curing agents. Formaldehyde is the most common hardening agent used in the plastics industry. Some of the plasticizers used with cellulose acetates also act as hardening agents; triphenol phosphate and ethyl acetanilid.

Solvents are used to dissolve the material so that it will flow. For cellulose plastics acetone, alcohol, and alcohol-ester blends are used. Other solvents used are amyl acetate, butyl alcohol, amyl propionate, and glycol esters.

Catalysts do not become a part of the finished plastics material—they assist the elements of a mixture to combine as compounds and may affect the character of the resultant compound. Catalysts such as caustic soda, caustic potash, hexamethylenetetramine, water, or sulphuric acid, are required for most synthetic resinoids.

Accelerators are designed to hasten the curing or hardening process with thermosetting plastics. "For phenolics, magnesia and powdered lime are used as accelerators, and for ureas, powdered oxalic acid, zinc chloride and certain esters are recommended" (72-26).

SOURCES OF RAW MATERIALS

Manufacturers of base materials secure, at the outset, raw materials necessary for producing fillers, binders, lubricants, and all the rest of the basic materials of manufacture. Since space will not permit an outline and description of all materials, particular reference is made to those used in the manufacture of binders.

The process of securing the raw materials begins with quite common compounds. Two common substances, wood and cotton, are

shown in Figure 26 and the flow of production is carried to the resinous materials which are obtained. There follows a list of additional common compounds, but some of the chemicals which are derived from them are outlined. They are all used in producing some type of synthetic plastics.

Air
1. Oxygen
2. Nitrogen
   - *a.* Ammonia
   - *b.* Nitric acid

Coal
1. Coke
   - *a.* Carbon
   - *b.* Lamp black
2. Tar
   - *a.* Alizarin
   - *b.* Aniline
   - *c.* Benzene
   - *d.* Coumarone
   - *e.* Indene
   - *f.* Naptha
   - *g.* Naphthalene
     - (1) Phthalic anhydride
   - *h.* Phenol
   - *i.* Xylenol

Limestone
1. Calcium carbonate
   - *a.* Calcium carbide
     - (1) Acetylene
     - (2) Acetic acid

Petroleum
1. Ethylene
2. Ketene
3. Propylene

Plant wastes (oat hulls, etc.)
1. Pentosan

Salt
1. Chlorine
2. Hydrochloric acid
3. Sodium hydroxide
4. Sulphur
   - *a.* Sulphuric acid

Water
1. Oxygen
2. Hydrogen
   - *a.* Ammonia
   - *b.* Menthanol
   - *c.* Formaldehyde

PRODUCTION OF SYNTHETIC SOLIDS

Perhaps most important of all the materials used by manufacturers in producing synthetic plastics is the resinoid binder. It is the binder that determines the nature of the completed plastics solid. The composition of the binder varies with each process used for shaping and curing the material. Catalysts, hardeners, plasticizers, and fillers will each modify the character of the binder, so all of these factors must be considered.

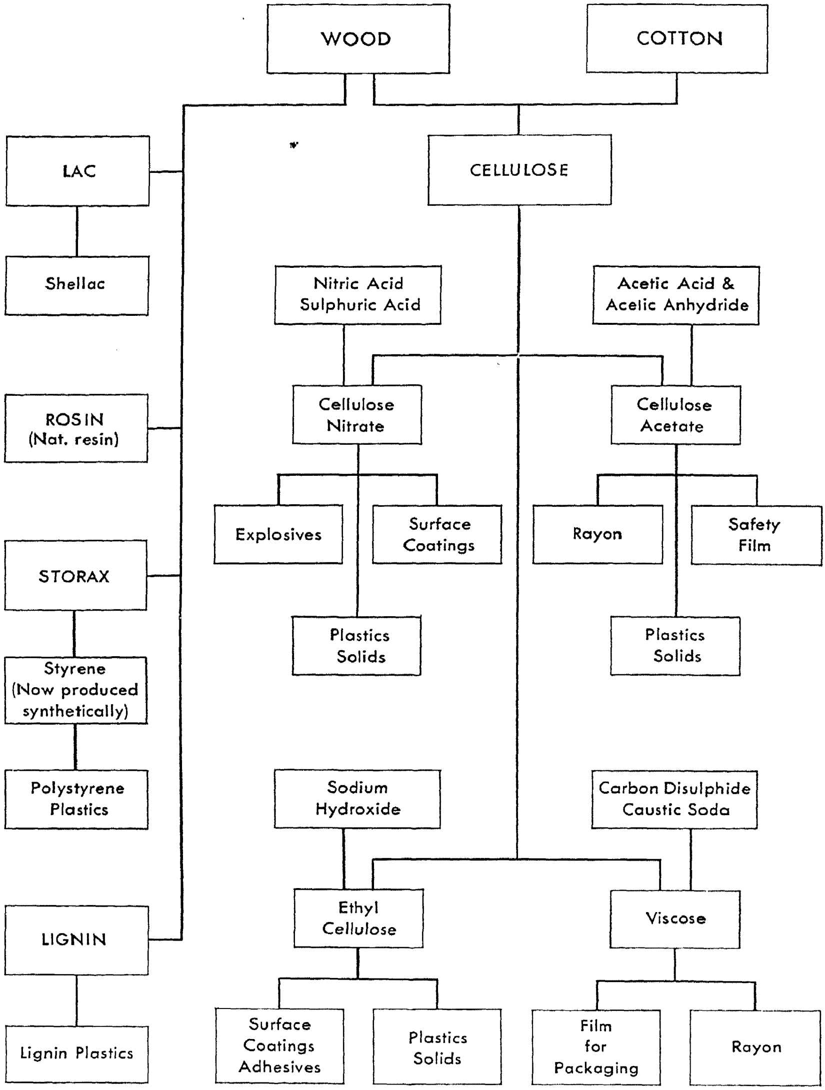
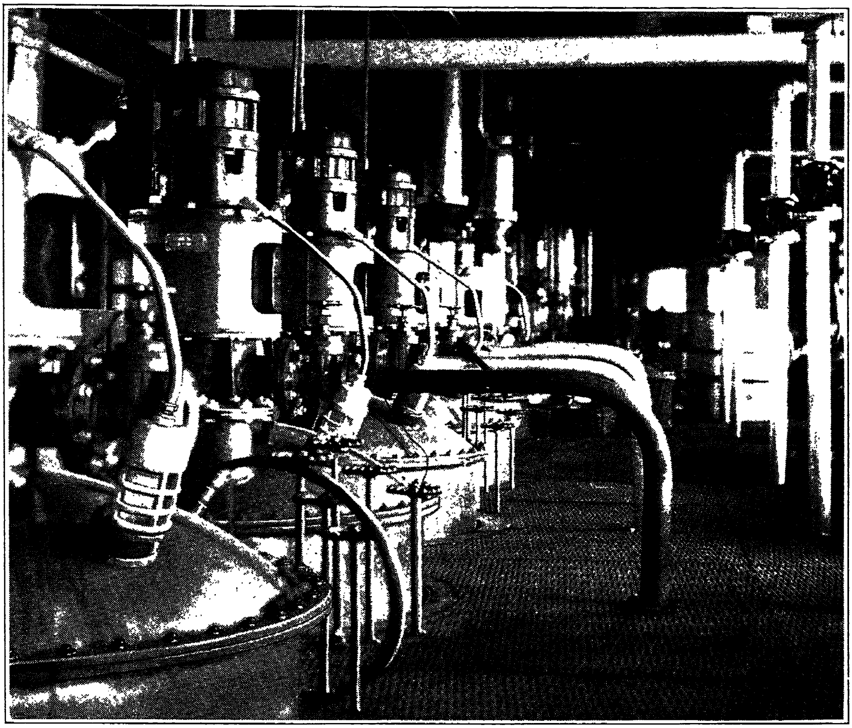


Figure 26. Flow chart showing resinous materials derived from wood and cotton.

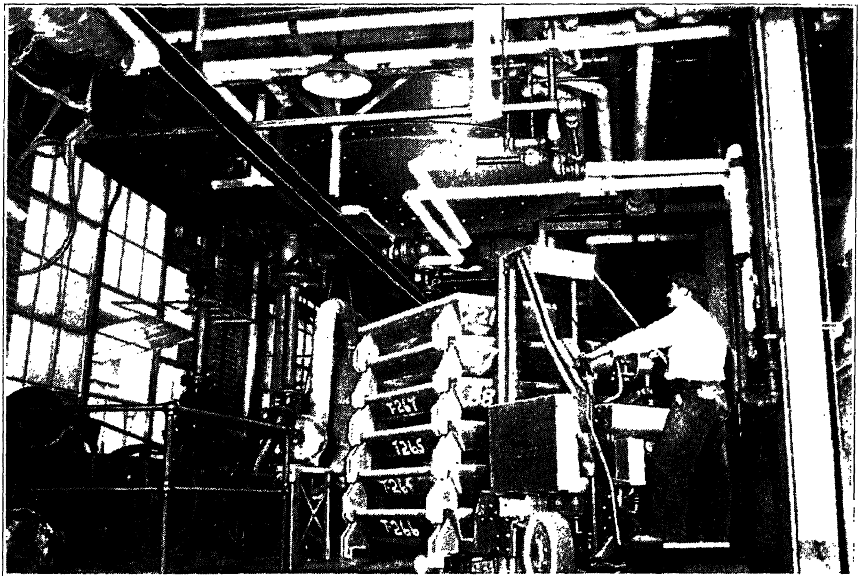


(Courtesy of the Catalin Corp.)

Figure 27. Kettles used in preparation of the resinoid.

Three common processes are used for changing a liquid resinoid to a solid substance: molding, casting, and laminating. In each of these processes heat and curing-time are involved. In the molding operation and in the laminating operation pressure must be exerted by some type of press. With the exception of a few rough edges due to flashes and the like, plastics surfaces come from the presses finished and ready for use. Cast resinoids, however, require a surface finish after curing takes place.

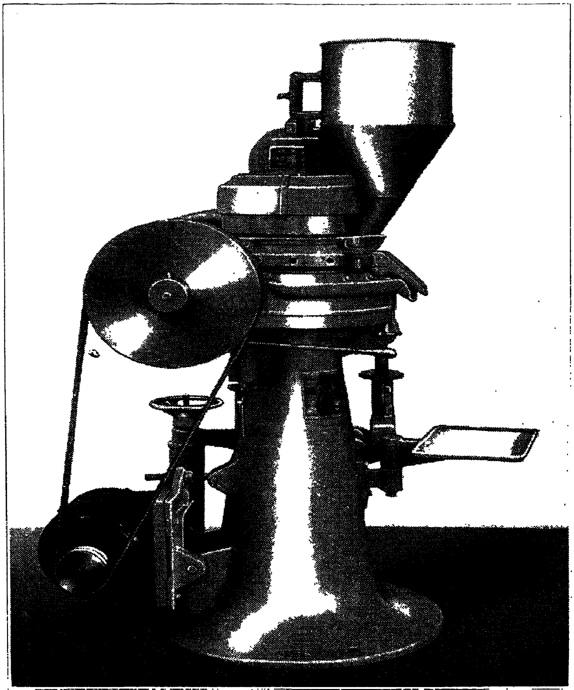
Molded Plastics.—Molded articles of plastics are produced by placing a quantity of a molding composition in a cavity and applying heat and pressure. Under heat, the compound flows into the mold cavity and assumes its shape. A slight flash has to be removed, the edge polished, and molding is complete.



(Courtesy of the Bakelite Corp.)

Figure 28. Like molten lava the liquid is discharged from the stills overhead into giant nested trays which are carried by trucks to the cooling

To outline the preparation of a typical molding compound, a phenolic resinoid has been selected. Phenol (prepared from benzine and air) and formaldehyde (prepared from methanol) are brought together in carefully weighed proportions, in a huge kettle in the presence of a catalyst such as caustic soda. The kettles are nickel lined and may have a capacity of 3000 pounds of resinoid. A battery of these kettles is shown in Figure 27. After being cooked for a time and kept in motion by an agitator placed at the center of the kettle, the phenol and formaldehyde combine into a fusible, honey-like, resinous mass. The liquid resinoid is drawn off into shallow containers (see Figure 28) where it is permitted to cool quickly. As it cools, it hardens and must be broken up and ground to a powder. At this stage, the powder has filler and coloring materials added and is introduced to heated rolls. A thorough mixing and kneading takes place as the plastic mass passes between the rolls. Heat from the



(Courtesy of F. J. Stokes Machine Co.)

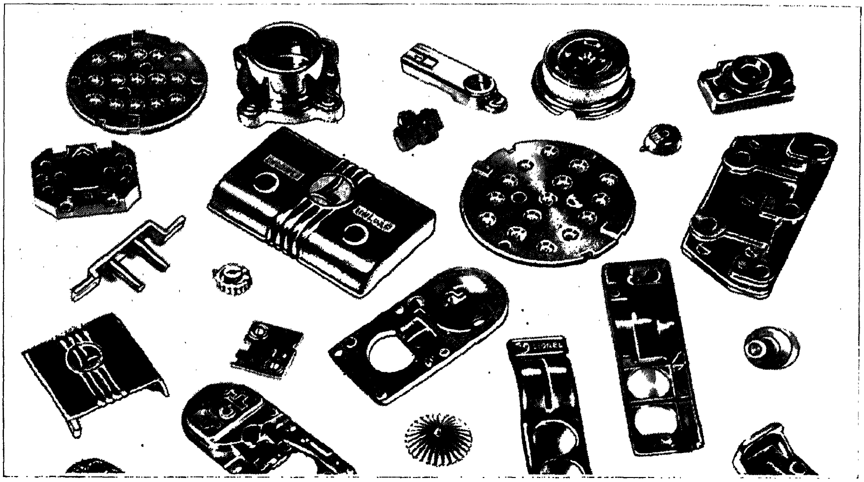
Figure 29. Rotary tablet or pill machine.

rolls starts the curing process which is permitted to advance to the "B-stage" or to a point where it will harden rapidly when placed in a molding press.

The plastics is reground and the granular powder passed over magnetic separators to remove any small particles of metal which may have been introduced into the mass by accident as it passed through the various processes. After the powder has been blended to insure uniformity, it is ready for a molding plant—it is now properly called a *molding compound.*

Molding Compounds.—A molding compound is prepared to suit the type of press and the type of mold upon which it is to be used. Three forms, granulated, powdered, and pilled, are available. The name of each form indicates, to a degree, its nature. Granular com-

pounds have been ground into rather coarse, grain-like particles. Molding powder is finely ground or pulverized material. Pilled compounds are prepared by running medium ground powder through a special pilling machine which presses the powder into the rough shape of the finished molding. The weight of each pill, or *preform*, is slightly more than the molding made from it, thus insuring a completely filled cavity. Any excess of compound escapes between the halves of the mold.



(*Courtesy of F. J. Stokes Machine Co.*)

Figure 30. Preform parts.

Preforms are very convenient to use because they can be handled easily and because they eliminate mold waste. They can be preheated before they are placed in the press for molding. Figure 30 shows a variety of preforms. Color is present in the preforms as in the molded parts and it is possible to detect different textures, which indicate a variety of molding compouds, among the parts.

Types of Molding.—Two expensive items of the molded plastics industry arise from the huge presses which are required to do the molding job and from the molds or dies which must be constructed for use on the machines. In preparing the dies, skilled work-

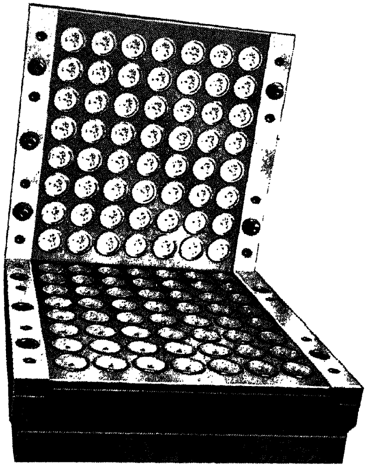
Figure 31. Die-maker at work with a graver on a button die.

men are needed, expensive machinery is used, and high-priced metals are selected. All molded parts assume a surface like that of the die in which they are molded. Any tiny scratch or rust pit will show in the molding. Die surfaces are, therefore, often chromium plated. Some notion of the intricacy of the work of a die maker may be obtained from Figure 31.

Molds are used many times; therefore, their surfaces must be hardened to resist wear. Oftentimes a mold contains many identical cavities, and there is need for a machine process which will make identical parts from a master model. On some types of molds, a duplicating machine is used to make several molds like the original. At other times it is possible to *hob* out molds of intricate design. A hardened steel die is pressed into the surface of softer steel so that the impression is like the original, but the reverse of it.

A careful selection of mold steel must be made if it is to meet the demands upon it. Some of the properties required are hardenability, machinability, hobability, uniformity of structure, freedom from non-metallic elements, high strength, and good finishing properties. Spraying metal on a form is another method of duplicating

a mold. Molten metal is sprayed on a form or matrix shaped like the desired mold. The metal shell thus formed needs only to be backed up with a substantial support.



(Photographed at the Consolidated Molded Products Corp.)

Figure 32. Block of button dies showing both halves of the die.

(*a*) *Compression Molding.*—In the compression-molding process the mold is divided into two sections and the molding compound is placed in the lower section. As the press closes heat is applied from live steam or electric heating coils. Hydraulic pressure is often applied. The mold is closed long enough for a cure in the plastics to take place. The mold must be cooled by a fluid passing through the cooling channels. When the press opens, a solid molding, rather than one in a plastic state, is removed. A molding cycle is thus completed.

Compression molds are classified as positive, semi-positive, and flash types. A *positive mold* confines the material completely. There is no cut-off section. Mold charges must of necessity be accurately weighed. *Semi-positive molds* are most commonly used. The material

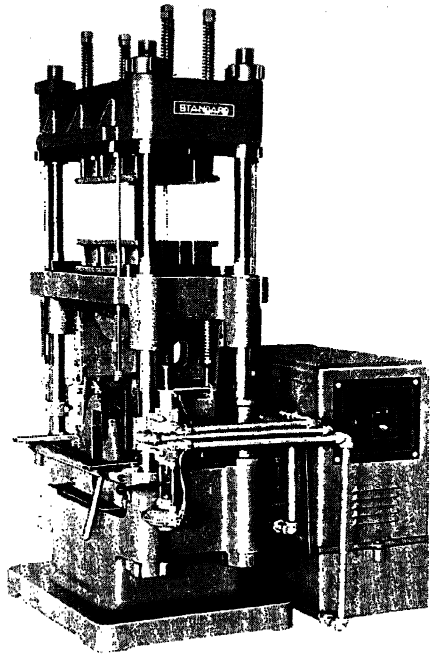
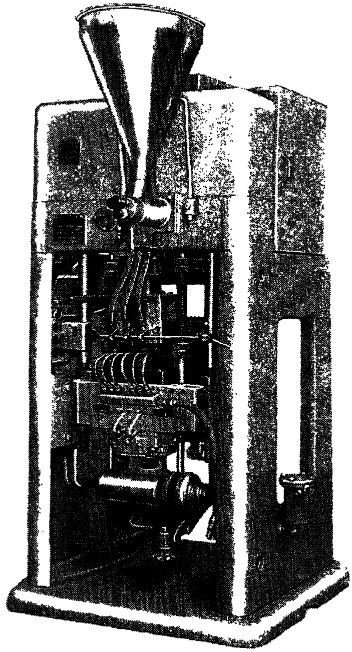


Figure 33. *Standard 150-ton semi-automatic hydraulic molding press with enclosed power unit and time cycle controller.*



(Courtesy of F. J. Stokes Machine Co.)

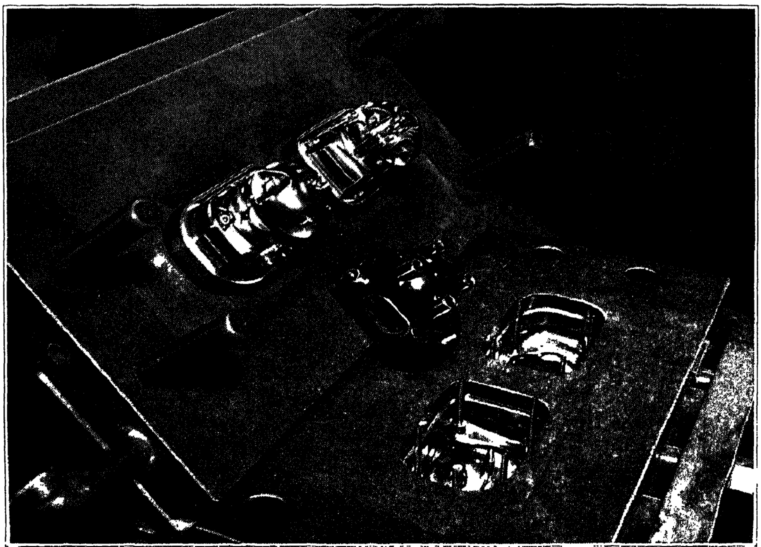
Figure 34. *Fifteen-ton completely automatic molding press with triple feed device and triple unscrewing device.*

is only partially confined, since there is some provision for overflow. Weight of the mold charge is slightly in excess of molding weight. A *flash-type mold* is adapted for thin, flat articles where the compound is not confined until final closing of the mold takes place. A fourth type of mold has a common loading cavity and a series of subcavities. This mold may be of positive or semi-positive design.

Compression molding permits the molding of large articles which cannot be molded by the injection method. It makes possible more closely regulated variegations of color because the mixture of the molding composition can be controlled. This type of molding is well

adapted to phenolic molding compounds and to cellulose nitrates. Other types of resinoids can be molded by any type of press.

(*b*) *Injection Molding.*—The first injection molding press was imported into the United States in 1934. To date, therefore, injection molding has not developed into a science, but many things have been learned about it. Figure 36, illustrates the principle of injection molding.



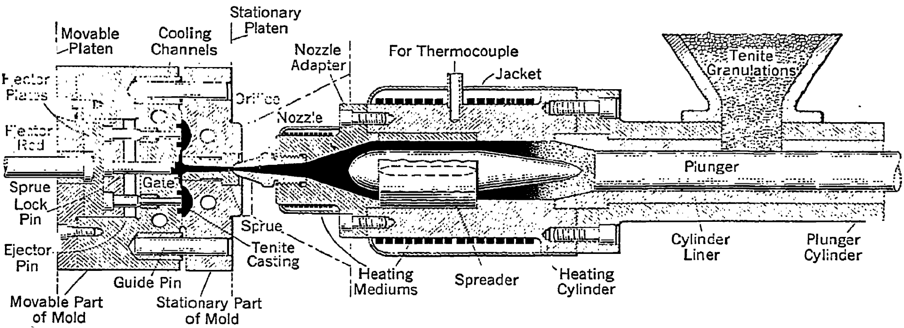
(*Courtesy of the Consolidated Molded Products Corp.*)

Figure 35. Eisemann distributor cover molded of phenol-furfural plastics. Both male and female parts of the die used in the molding are shown.

From the sectional view the reader will note that there are two principal parts to an injection mold. The *movable* part of the mold (usually to the operator's left) is fastened to the movable platen and houses the ejector mechanism. The *stationary* part is attached to the stationary platen and comes in contact with the nozzle from the injection cylinder. Molds may be single-cavity or contain as many as forty cavities. On close fitting molds some provision must be made for air to escape; otherwise the cavities will not fill completely or the molding will contain air bubbles. Usually a tiny scratch from each

cavity is all that is necessary, for the extreme pressure will reduce the volume of air to $\frac{1}{500}$ of the original.

For injection molding, it should be noted that molding granulations are rather large, as compared with those in compression molding. Cellulose acetate works well with $\frac{1}{8}''$ to $\frac{3}{16}''$ granules. Constant heat of from 330 degrees to 480 degrees F. is maintained in the heating cylinder. Molding compound forced into the heating cylinder by

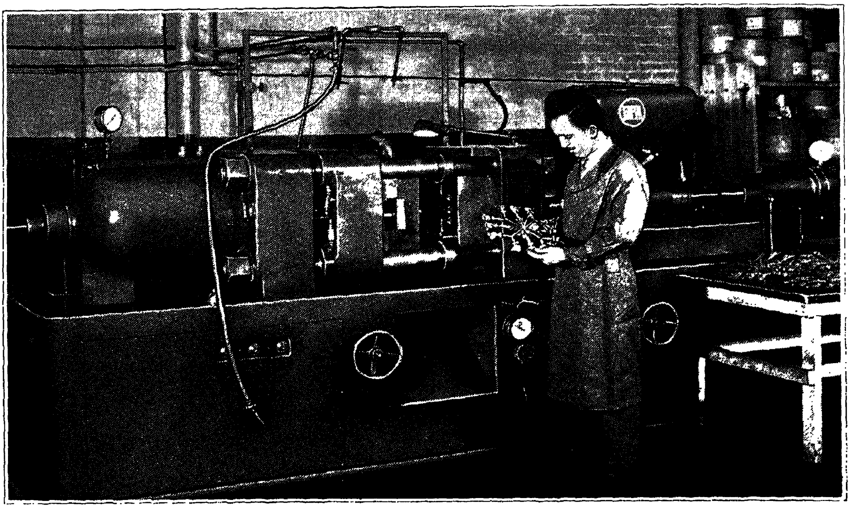


(Courtesy of Tennessee Eastman Corp.)

Figure 36. Sectional view illustrating general method of injection molding.

the plunger has an opportunity to remain there long enough to reach a plastic state in which it will flow readily. When the press is opened, the plunger has dropped back of the feed hopper to catch a new supply of plastics. As soon as the press is closed again, the plunger starts forward and forces the flowing plastics through the nozzle, through the sprue, through each runner and gate which leads to each cavity, and continues until all cavities are filled. This action must be rapid, for all cavities must be filled before the plastics cools enough to set. Hot plastics will give up their heat to the movable part of the mold, so that cooling channels are necessary.

The chief advantage of injection molding over compression molding lies in fast production. To compare the two, four to six cycles per minute are accomplished by injection molding, as compared with an average rate of six minutes per cycle for compression. This difference is due largely to the fact that the whole mechanism of a compression press must be heated and cooled for each cycle. In an



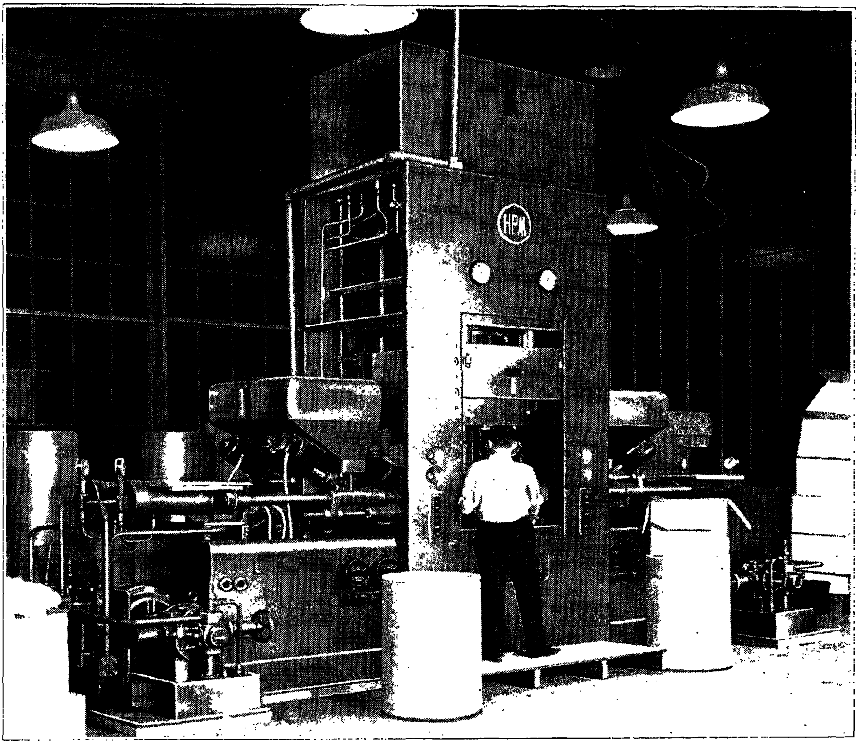
(Courtesy of the Hydraulic Press Mfg. Co.)

Figure 37. A single injection unit, hydraulic injection-molding press.

injection press, the plastics is held at a constant temperature and the movable part of the mold is kept at a constant temperature also—time is not required for cooling before the press can be opened. This type of molding has made possible the covering of metal cores with an attractive plastics coating—automobile door handles, for example.

Figure 37 shows an injection-molding press with a maximum clamping capacity of 350 tons, a mold size of $16\frac{1}{4}''$x$30''$, and a weight of 23,500 pounds. The press in Figure 38 has four nozzles or injection units, has a maximum clamping capacity of 500 tons, has a mold size of $36''$x$48''$, and has a weight of $36\frac{1}{3}$ tons. The latter press can mold a refrigerator panel weighing one pound at the rate of fifty cycles per hour. Another press (smaller) with a six-cavity mold and using $2\frac{1}{2}$ ounces of compound per cycle has a production rate of 120 cycles per hour.

Another very definite advantage of injection molding is the possibility of using scrap material. All of the gates, runners, and sprue on the molding in Figure 39 can be cut off, reground, and used again. There need be no waste from this type of molding.

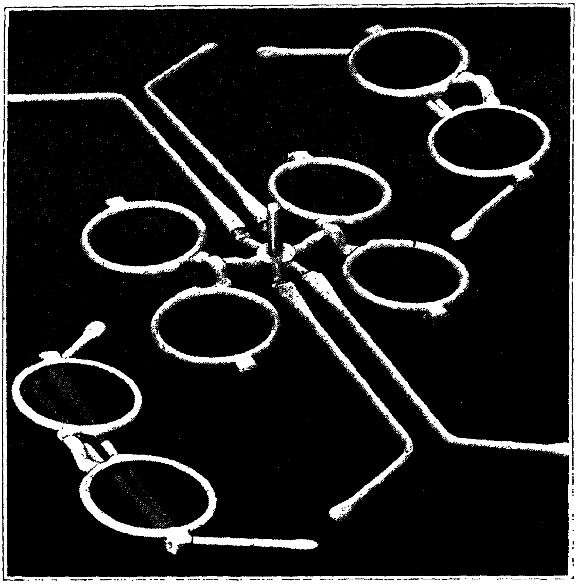


(*Courtesy of the Hydraulic Press Mfg. Co.*)

Figure 38. A multiple injection unit, hydraulic injection-molding press.

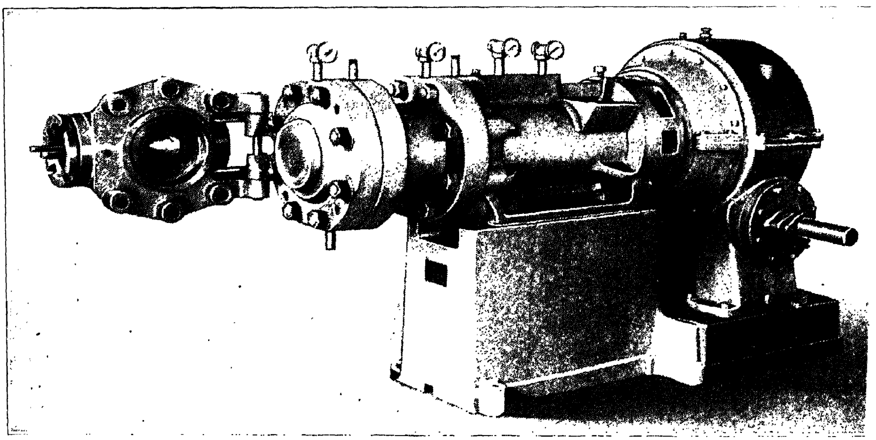
(*c*) *Extrusion Molding.*—The process of fabricating by extrusion is essentially that of building up pressure behind a comparatively large volume of plastic material which is allowed to escape through a small opening like tooth paste from a tube. A cross-section of the extruded material is identical with that of the nozzle opening. In the actual process of extruding plastics, many factors such as providing heat to accomplish plasticity, odd cross-sectional shapes, and caring for the extruded material until it has cured, serve to complicate the procedure.

For more than fifty years extruding machines have been used on some type of plastics, but the process of extruding is still new insofar as general knowledge is concerned. The early use of these



(Courtesy of Tennessee Eastman Corp.)

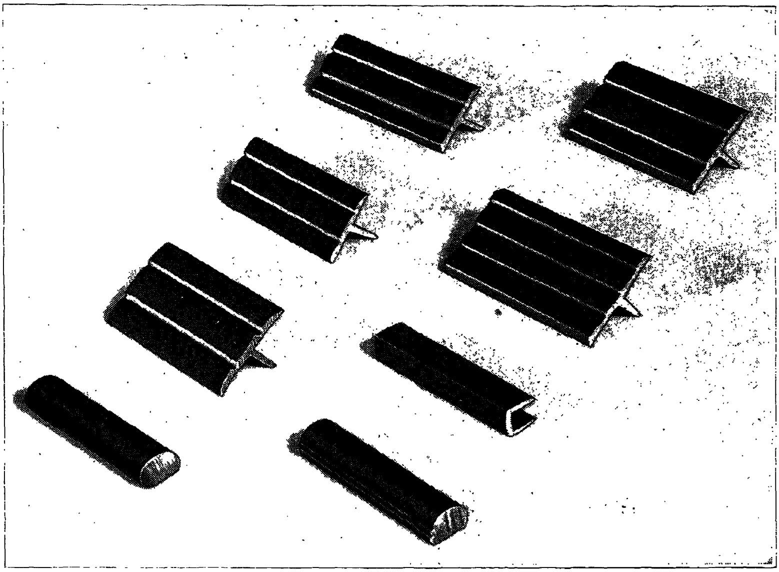
Figure 39. Spectacle frames as they come from a multiple cavity, injection-molding press.



(Courtesy of John Royale & Soi

Figure 40. Plastics extruding machine with side-delivery head open for clean

machines was for extruding casein rods from which button blanks were cut and for extruding tubes used for pen barrels from cellulose nitrate plastics. The main use of the extruding machine, since its invention in 1880 by Vernon Royle, has been in the rubber industry, where tubes, insulated wire, and channels have been produced.

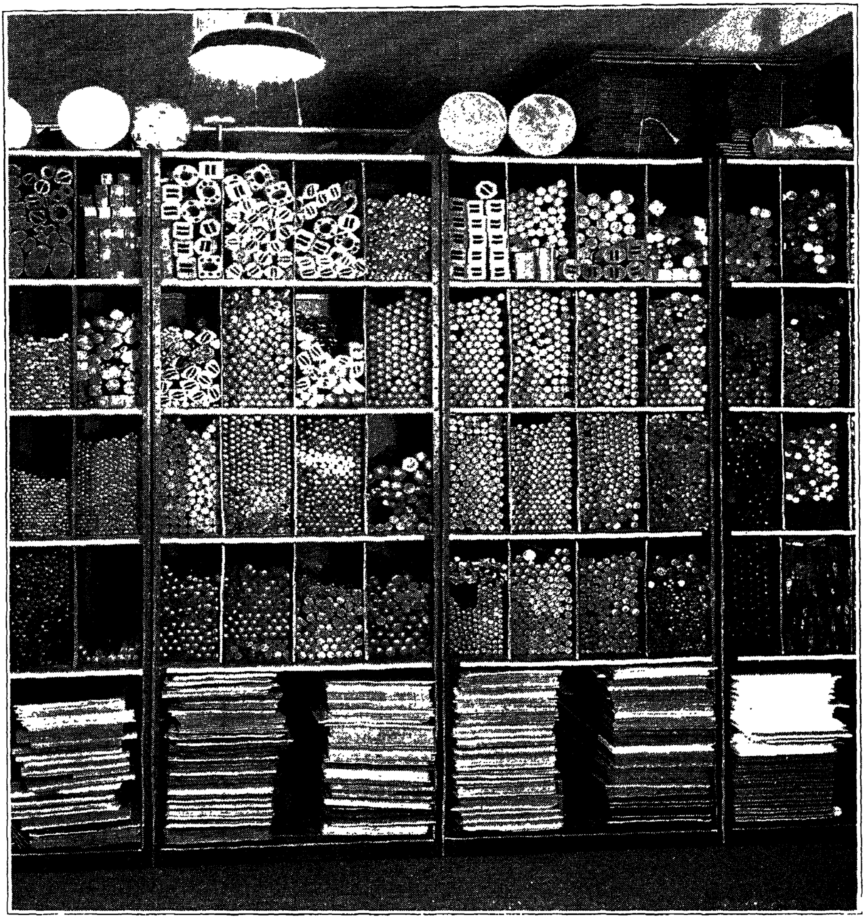


(Courtesy of the Plastikon Co.)

Figure 41. Extrusion molded plastics shapes.

Practically all of the synthetic plastics may be adapted to some form of extrusion molding, but it is the thermoplastics which lend themselves most readily to this type of fabrication. Each plastics requires individual treatment—methacrylate plastics leave the die (nozzle) crystal clear and highly polished, but polystyrenes must be polished. Die surfaces must be quite smooth and oftentimes chromium-plated to reduce friction and to insure a smooth surface on the extrusion.

Special care must be taken of a continuous extrusion, because it it not completely cured and is easily pressed out of shape. Continuous extrusions are usually run out on a conveyor belt timed to the speed

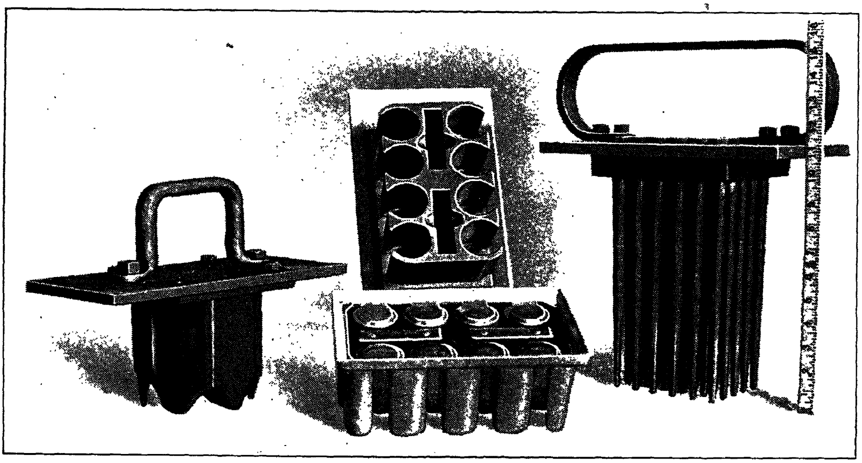


(Courtesy of the Catalin Corp.)

Figure 42. A section of a Catalin Corporation stockroom showing a store of cast resinoids.

of the machine or on an incline where they slide down by gravity. To make the conveyor more accessible, extrusion machines have been designed with the extrusion head at right angles to the body of the machine.

Cast Plastics.—Casting of synthetic resinoids is similar to the casting of metals—a mold is prepared, a liquid substance is poured into

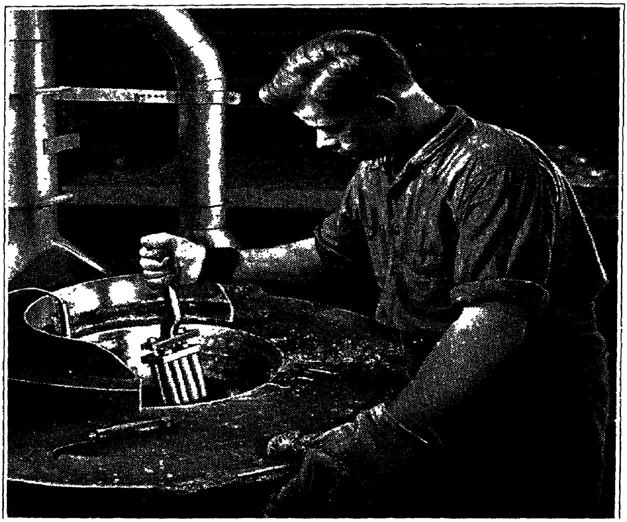


(*Courtesy of the Catalin Corp.*)

Figure 43. Dies, hollow form, and castings used in preparing cast plastics.

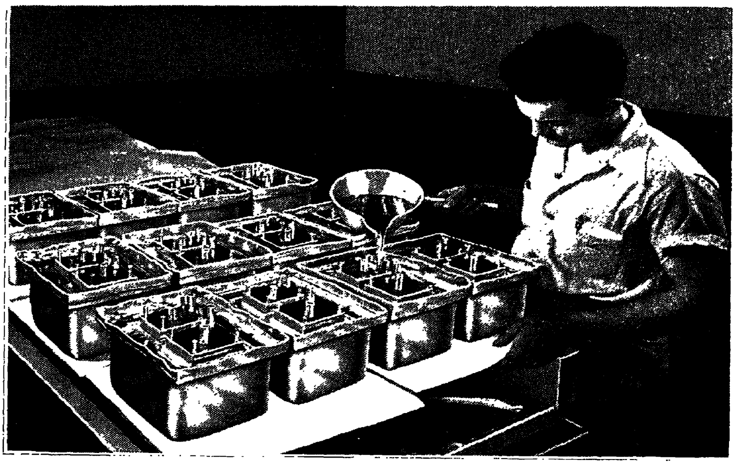
the mold, and the compound is allowed to set. The preparation of resinoid for casting is similar to the preparation outlined for molding on page 48, except that plasticizers, accelerators, dyes, and pigments are added to the reaction kettle where the resinoid is formed. Resinoid is drawn from the reaction kettle in liquid form and is poured by hand into prepared lead molds. As soon as the molds are filled, they are transferred to curing ovens until the resinoid has set. The series of illustrations from Figure 43 to Figure 48 carry the processes outlined from the preparation of a lead mold to a completed radio cabinet.

Dies.—The initial step in preparing a mold for casting is the shaping of a suitable die. The die is a piece of steel the same shape as the plastics part which is desired. All dies must have a slight taper from one end to the other to permit the removal of the die from the mold and the withdrawal of the casting from the mold. On a one-piece die, under-cuts are impossible, but split molds which will permit this type of design have been perfected. The dies should have polished surfaces and should be hardened, because they determine the finish of a casting and because they must be used many times.



(Courtesy of the Bakelite Corp.)

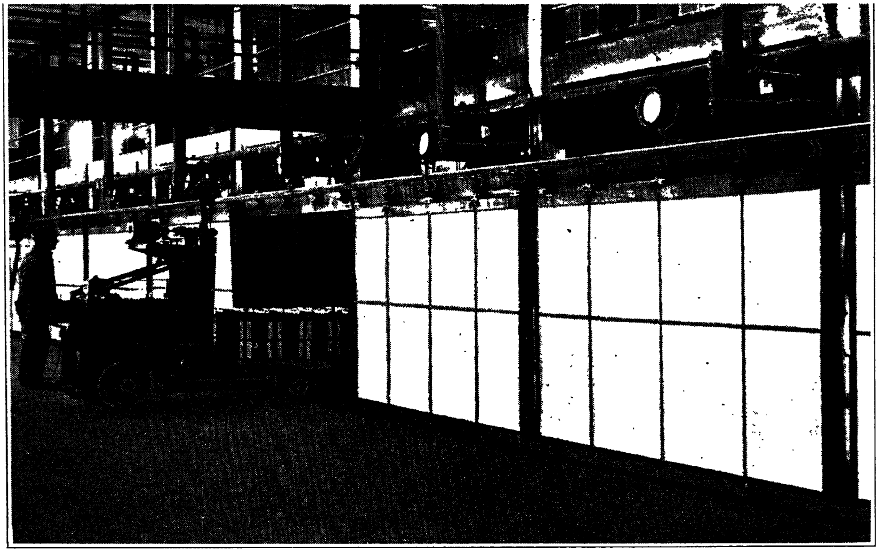
Figure 44. Dipping steel arbor into molten lead to form lead mold.



(Courtesy of the Bakelite Corp.)

Figure 45. Pouring liquid resinoid into radio cabinet lead molds.

Molds.—In the case of simple shapes, several dies are mounted together on a single arbor plate so that the molds may be made more quickly and placed more compactly. Molds are made by dipping arbors or single dies into molten lead. The cold arbor chills that portion of lead which comes in contact with it and, when it is removed, a lead shell clings to it. Because of the tapered dies, the molds may be removed from the arbor quite readily. The lead molds are stacked close together (open end up) on a rack and are ready for filling.



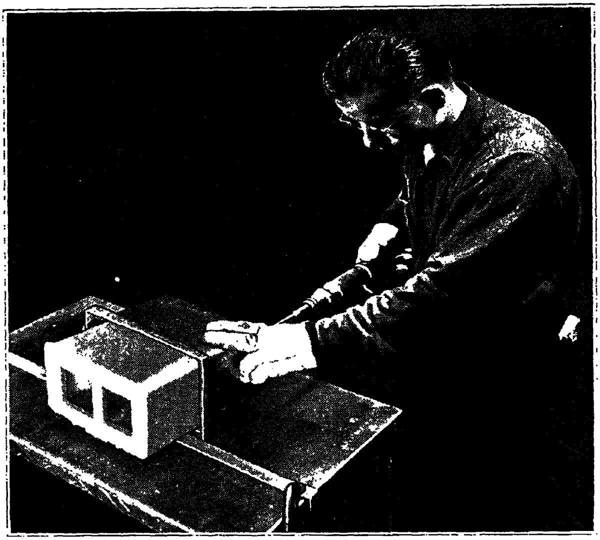
(Courtesy of the Catalin Corp.)

Figure 46. Curing Ovens.

Pouring.—Liquid resinoid drawn from a reaction kettle into heavy gallon pans is poured into the lead molds. After a rack of the molds has been filled, excess resinoid is scraped off of the top of the molds so that unit castings will not have to be broken apart after the resinoid has cured. The body color has already been secured by mixing in the reaction kettle, but marbled or variegated effects are sometimes desired. This effect is secured on a mixing table by dipping a paddle back and forth between two or three different col-

ored batches of liquid resinoid. The colored paddle is dipped into a pan of liquid drawn from the reaction kettle and stirred slightly so that a marble-cake effect is secured. The colored resinoid is then poured into the molds.

Curing.—From the pouring room, filled molds are moved to ovens where they are subjected to thermostatically controlled heat at atmospheric temperatures. The temperature for a particular cure seldom exceeds 85 degrees Centigrade. The curing time extends over

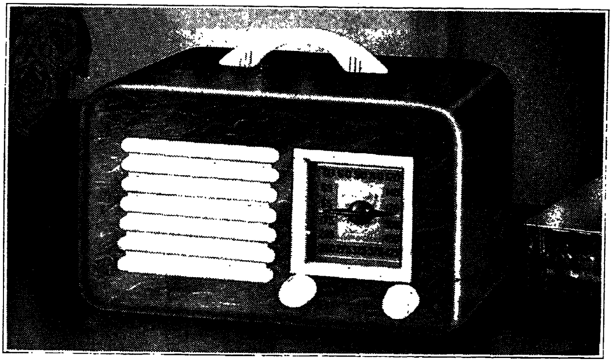


(Courtesy of the Bakelite Corp.)

Figure 47. Removing cured casting from lead shell.

a period of time up to five days, depending upon the size of the castings. Chemical reaction continues under heat and the sticky mass gradually changes to a solid material. In the case of thermosetting plastics, the shift is from an A-stage resinoid through the B-stage to the C-stage, which is identified as an infusible and insoluble mass.

Cured or polymerized castings are removed from their lead forms by air hammers. In this operation the thin lead forms are bent out of shape, but they are not scrapped—they are melted and used again.



(Courtesy of the Bakelite Corp.)

Figure 48. Finished radio cabinet.

New forms are placed in stock or shipped to fabricators or jobbing houses.

A variation from the usual curing procedure is effected by interrupting the polymerization process long enough to slice heavy blocks into thin sheets on a slicing machine when the plastics is in a jelly-like mass. Another process takes the plastics at this stage of polymerization and presses it between dies to form many new shapes such as plates, shallow bowls, and embossed surfaces. Curing is then continued as usual.

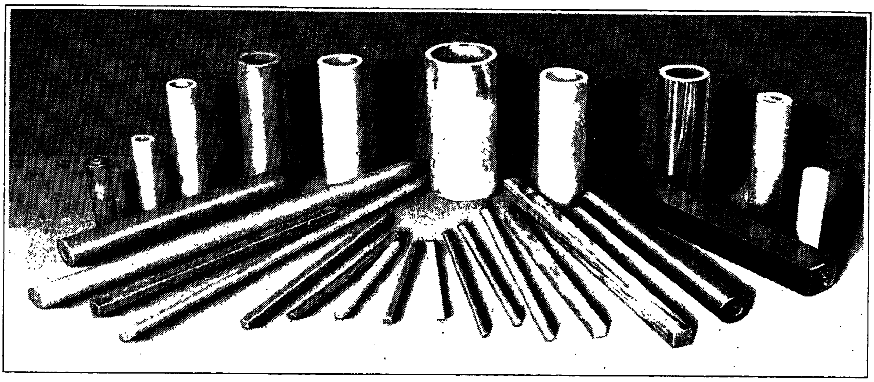


Figure 49. Miscellaneous stock sizes of cast rods and tubes obtained from a jobbing house.

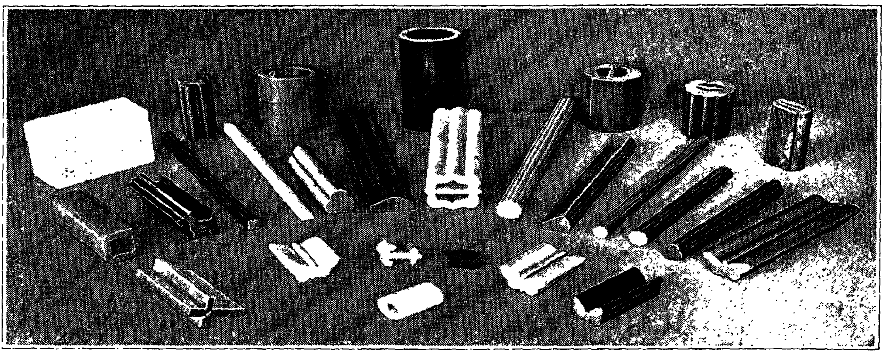
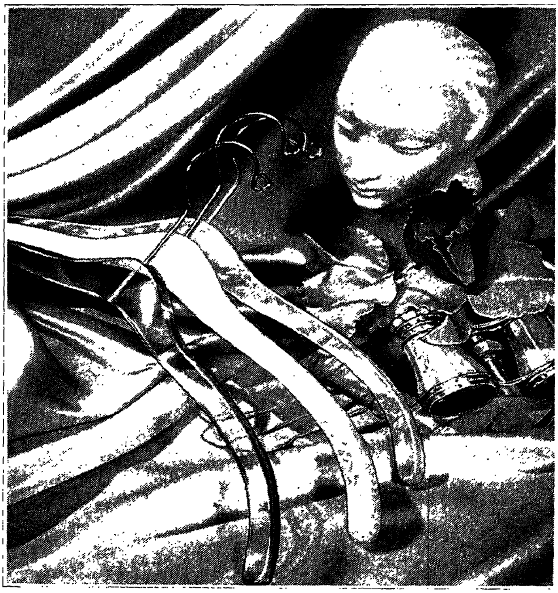


Figure 50. Cast resinoids in special shapes.



(Courtesy of the Catalin Corp.)

Figure 51. Coat hangers.

Cast Shapes.—Standard castings in the form of sheets, rods, and tubes have been produced from the time cast resinoids were brought upon the industrial scene. These shapes were standard with fabricators who could, by various machine operations, produce many commercial products. Many special shapes have been developed as standard mold forms by manufacturers of cast resinoids. Other cast forms, such as radio cabinets, may be produced with much less expensive equipment than is required for similar production on a molding press. A glance at Figures 42 and 50 will give some notion of the possibilities of special cast shapes.

A commonly used shape such as a drawer handle, a pin ornament, a belt buckle, or a coat hanger has been cast in rod form with a cross-section of desired shape. To produce duplicate parts, it is necessary only to cut off slabs from the rod, smooth the cut surfaces, add some surface enrichment, and finish the article. Special castings of this type will interest craftsmen as well as industrial fabricators, because wastage of material is eliminated. Figure 51 shows one article produced from such a casting.

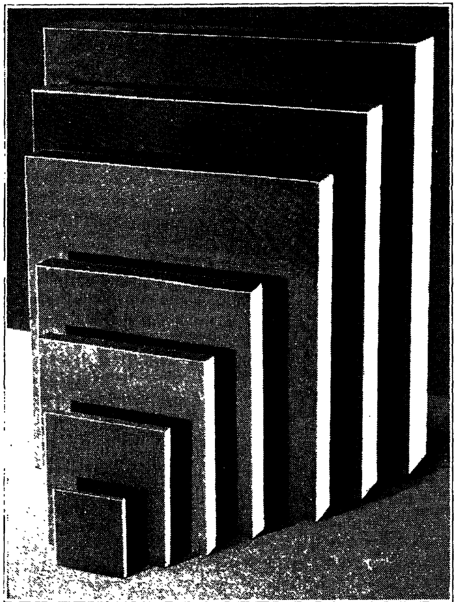
Cast resinoids come from their molds with an unfinished appearance unlike the glossy surface of a molded article. Transparent castings, in particular, show frosted surfaces. The removal of mold glaze and preparation of a high gloss are finishing operations which are explained in Chapter 6.

LAMINATED PLASTICS.—Another type, laminated plastics, has been developed to meet some very definite needs among plastics fabricators who provide the materials for many engineering applications. Laminated plastics is made from superimposed layers of fibrous or porous sheets coated or impregnated with resinoid and becomes a solid mass by the application of heat and pressure in a large hydraulic press.

Laminated plastics forms have an advantage over the other plastics forms in that they receive the benefit of mechanical reenforcement from the laminations; then too, they possess the insoluble and infusible properties of the resinoid binder. By varying the processes of manufacture, a laminated sheet may have the appearance of the

Laminated plastics may look like

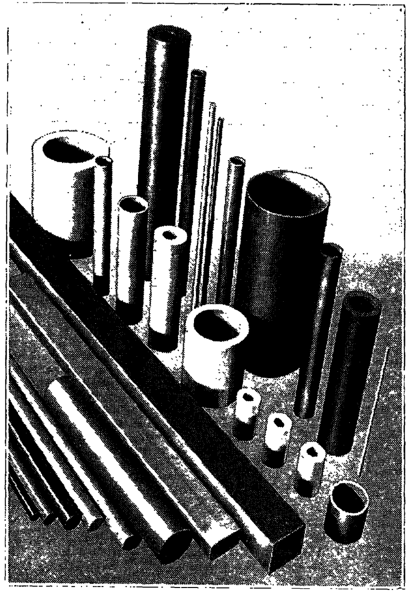
this



(Courtesy of the General Electric Co.)

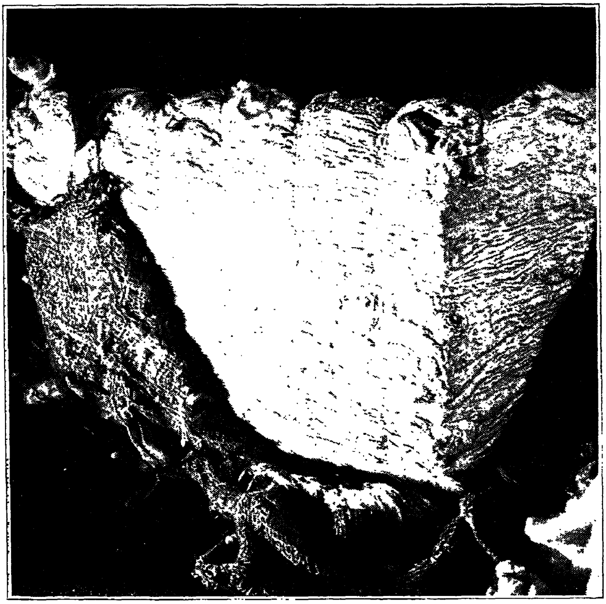
Figure 52. "Textolite" laminated sheets of various sizes with canvas as the base material.

or this



(Courtesy of the Synthane Corp.)

Figure 53.
"Synthane" laminated rods and tubes.



(Courtesy of the General Electric Co.)

Figure 54. Bale of unwoven cotton used in the manufacture of laminated plastics gears.

non-plastics layer (such as wood or canvas) or it may hide the base material, giving the appearance of a purely plastics product.

Base Materials.—Manufacturers of laminated plastics require a variety of materials which may be considered the *base materials.* Some of these base materials are listed as follows:

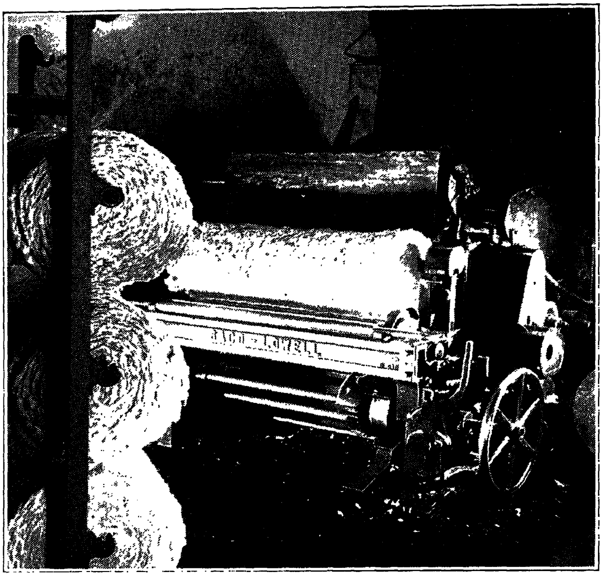
(*a*). Paper—rag, kraft, and asbestos;

(*b*). Fabrics—canvas, cambrics, percales, woven rayon, asbestos, and woven glass;

(*c*). Metal—perforated sheets (foils and screens);

(*d*). Wood—veneers (plain and woven).

Any of these base materials may be used alone or in combinations. Other materials such as mica and graphite may be used with the base sheets when special properties are desired. Graphite, when used



(Courtesy of the General Electric Co.)

Figure 55. Cotton emerging from a picking machine is wound into rolls upon a wooden mandrel.

with canvas in the manufacture of sheets from which gears and bearings are fabricated, provides splendid lubricating qualities.

Manufacturing Methods.—Large quantities of laminated phenolic sheets are fabricated into gears to turn the wheels of industry. An initial step in preparing the base material for lamination is the passing of unwoven cotton through a bale breaker. From the bale breaker, the cotton is carried through a blower pipe to the entrance of a picking machine.

In the manufacture of laminated sheets, the base layers are first saturated with a liquid resinoid, or they may be sprayed with a resinoid surface coating. The greater proportion of laminated plastics are made either from phenolic resinoid or from urea resinoid. Once the sheets have been impregnated, they are arranged in stacks of the necessary size to produce sheets of the desired thickness. As many as one hundred sheets or laminations of a fabric sheeting may be required to produce a cured bale one inch in thickness.

Having been arranged, the stack of impregnated laminates is placed between heated, polished steel platens of a hydraulic press similar to that shown in Figure 59. Here the heat and pressure are similar to those used in a molding operation. Under heat and pressure, the resinoid fuses the layers together and then sets into an insoluble and infusible mass which is tough and dense. The resulting sheet bears no resemblance to the original fabric or paper sheets from which it was made—it has been transformed into a homogeneous mass by the pressing operation.

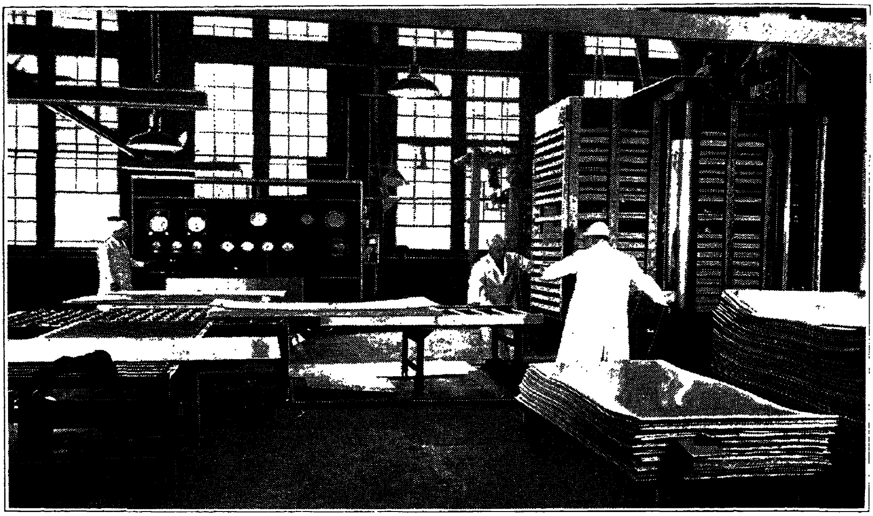
The surface finish of a laminated sheet is determined by the finish on the steel platen. A mirror surface on the steel plate will produce a glossy plastics surface; a satin finish is produced by a satin finish on the plate, and an engraved or Morocco finish on the metal plate will produce an identical surface on the plastics.

A typical press may produce sheets 3′ by 8′ in size and in a variety of thicknesses varying from $\frac{1}{16}''$ to 1″ or more in thickness. A total pressure of over five million pounds may be exerted by the press.

Laminated plastics are manufactured in tubes and rods as well as in sheets. In these forms, however, the manufacturing operations vary somewhat from those outlined for sheets. Impregnated paper or fabric sheets are wound on steel mandrels (corresponding in size to the desired inside diameter of the tube) under heat and pressure. After the tubes have been shaped to size, the resinoid may be cured either by placing the tubes in ovens or by placing them in shaped molds and applying heat and pressure. Tubes produced by the former method are referred to as *rolled,* while those by the latter method are referred to as *molded*.

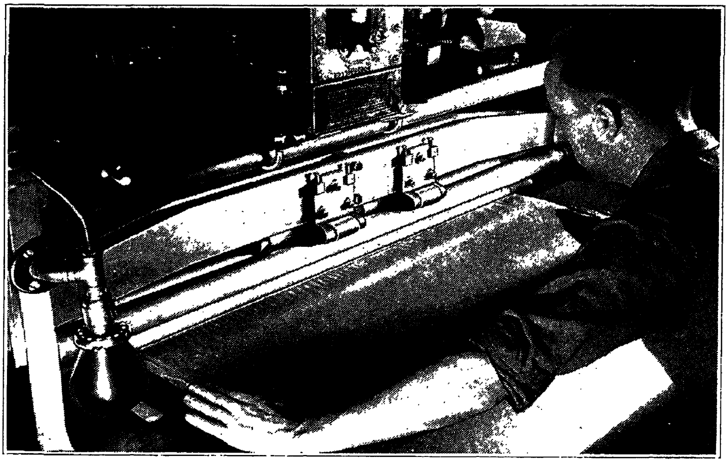
Following heat treatment, tubes are finished to accurate outside dimensions by removing them from the mandrels and grinding. For the rolled tubes greater dielectric strength and power factor are claimed. These types are also recommended where concentricity of inside and outside diameters is demanded. Molded tubes generally have a lower rating on moisture absorption.

Uses.—The laminated plastics are extremely versatile materials. They represent one of the most effective insulators and at the same time are light in weight—approximately one-half that of aluminum.



(Courtesy of the General Electric Co.)

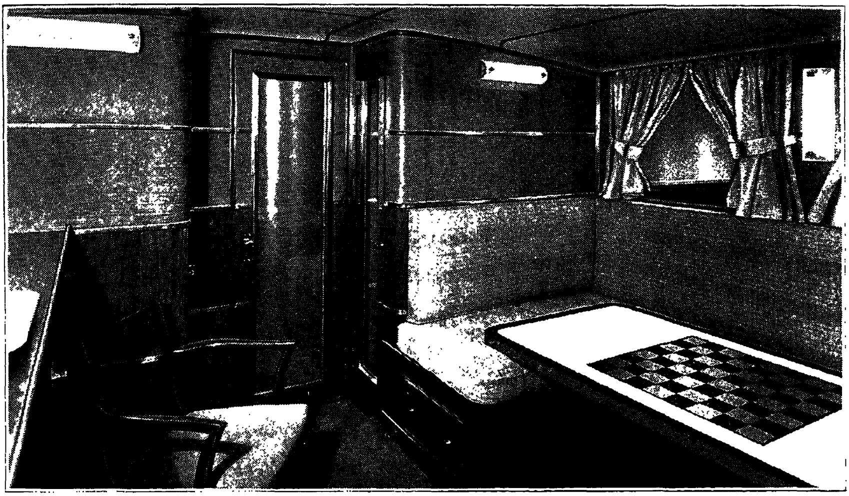
Figure 56. Loading a press with stacks of impregnated laminates.



(Courtesy of the General Electric Co.)

Figure 57. Rolling a laminated tube. The two upper rolls supply the heat and pressure for pressing and curing.

Properties common to most laminated plastics fall under the headings: (1) electrical—high dielectric strength, low moisture absorption, and low dielectric constant; (2) mechanical—light in weight; high tensile, flexual, and compressive strength; easily machined, tough, hard, sound-absorbing, and low heat conductivity; and (3) chemical—resistant to corrosion.

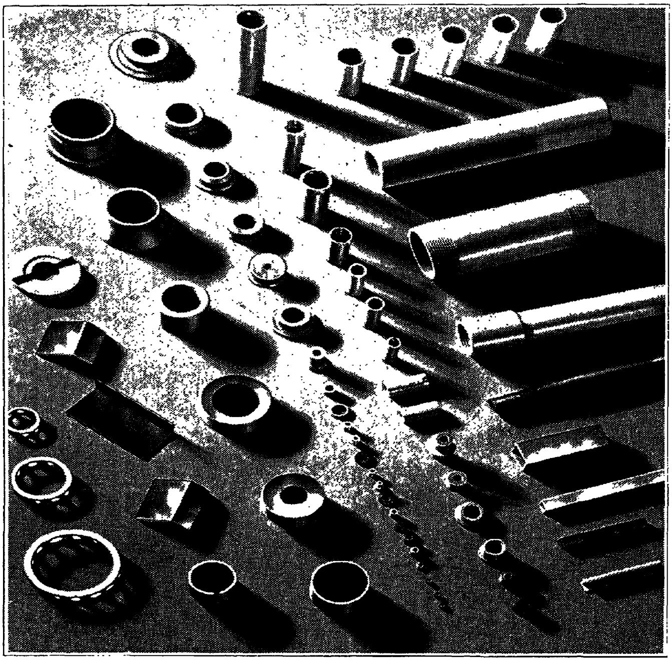


(Courtesy of the Formica Insulation Co.)

Figure 53. "Formica" paneling used on a yacht. The table top has an inlaid checkerboard of plastics.

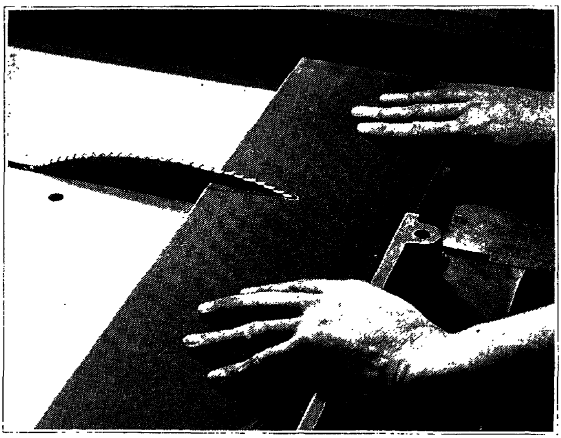
Uses for laminated plastics are found in the textiles, automotive, radio, and electrical industries, the building trades, and manufacturing industries. To mention specifically a few of the uses, the following utilities are made: bobbins, gears, pulleys, parts for ignition systems, bushings, bearings, washers, switches, relays, panels, socket bases, decorative paneling, waterproof and heat-resistant paneling, table tops, ball-bearing retainers, aircraft propellers, and aircraft fuselages.

Fabrication.—Laminated forms are easily machined and assembled by sawing, drilling, punching, riveting, turning, reaming, threading, tapping, knurling, and polishing. Figure 60 shows a laminated



(Courtesy of the Synthane Corp.)

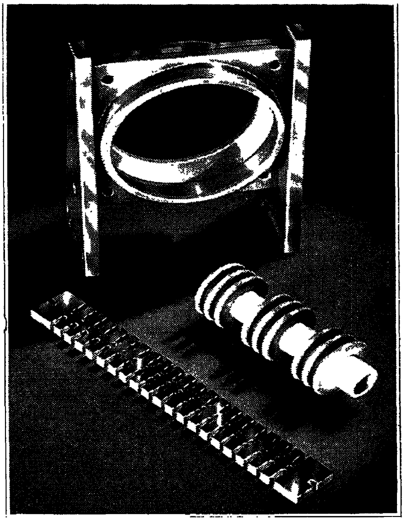
Figure 59. Parts fabricated from "Synthane" rods and tubes.



(Courtesy of the General Electric Co.)

Figure 60. Cutting a "Textolite" laminated sheet.

sheet being cut on a power saw. Both metal and wood tools are used successfully. Ordinarily wood-cutting machines are operated at lower speeds than those used for wood. A circular saw used for sawing laminated materials should be operated at 4500 to 6000 feet per minute on thin materials and at proportionately lower speeds as thickness increases. Hollow-ground saw blades with teeth having no set should be used.

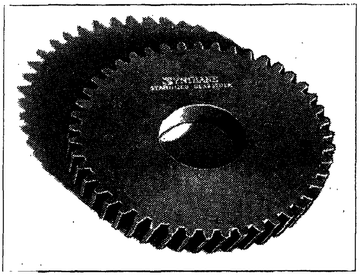


(Courtesy of the Synthane Corp.)

Figure 61. Variometer stator, mounting, high-tension insulator, and spacing strip machined from "Synthane."

Results of more complicated machining operations are represented by Figure 61. Milling, drilling, and turning operations have been performed on these parts. Figure 62 shows a gear wheel which has been machined from laminated gear stock.

Within the past few years, there have been developed real-wood laminated plastics materials. These materials are made by using on the outer layer a sheet of thin wood veneer which has been resinoid impregnated. A perforated sheet of metal foil may be placed near

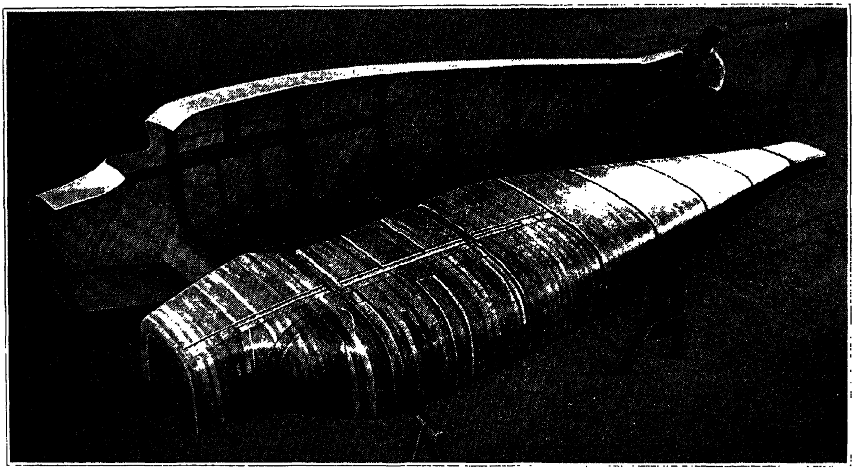


(*Courtesy of the Synthane Corp.*)

Figure 62. "Synthane" laminated gear.

the center of the laminates to provide strength. Plain wood, matched wood, and woven patterns from common and rare woods are available today. Wood-surface laminated sheets as well as those in solid colors are used extensively for paneling, table tops, and furniture.

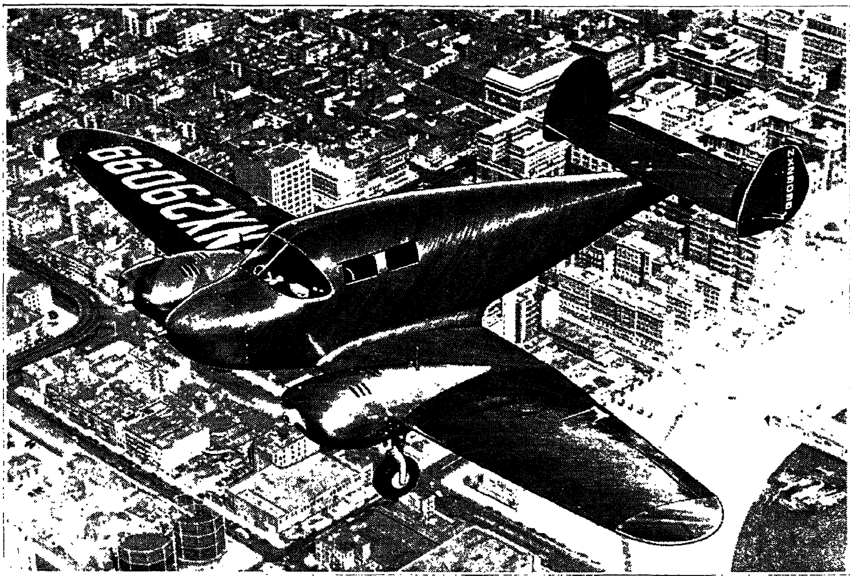
A more recent development in laminated plastics is the use of molded wood laminations. This development starts with a wooden form over which are placed several thin layers of resinoid-impreg-



(*Courtesy of the "Modern Plastics" Magazine*)

Figure 63. Workmen removing the plastics-plywood fuselage from the wooden form shown in the foreground.

nated wood. The layers are molded together inside a pressure tank. This type of molding is not to be confused with the processes surrounding the resin bonded plywoods which are on the market. It is not to be confused with the type of molding done from molding compositions—there a male and female die are used. Figure 63 shows the use of a male die only.



(Courtesy of the Langley Aviation Corp.)

Figure 64. Molded plastics-plywood airplane.

This molding process has been adapted to aircraft fuselages by the aircraft industry. Reenforcing members are molded into the shell without the use of any metal fastenings. The aircraft shown in Figure 64 is claimed to be the "first completely molded airplane that has ever been built."

APPLICATION OF PLASTICS

Uses for the various types of modern plastics mount into untold numbers. It would be be pointless to attempt to list all of them. A list of uses, authentic today, would be out of date tomorrow because

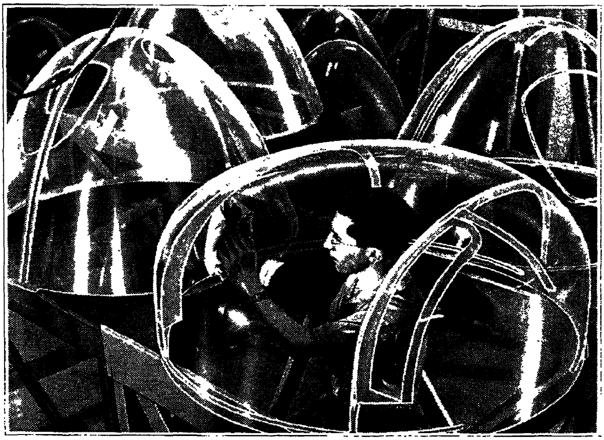
of rapid development within the industry. It has been estimated that there are 35,000 known uses for rubber. Compare your knowledge of the uses for rubber with your knowledge of the uses for plastics—now make an estimate of the uses for plastics. One manufacturer claims as many as 25,000 known uses for the synthetic plastics products of his own organization.

An analysis of any material which is enjoying industrial development reveals that the material can do something better than any other similar material. What qualities make this possible? Why is metal being replaced by extruded plastics for panel edging? Why is wood being replaced by laminated plastics for table tops? Why are occasional tables being fabricated from thermoplastic materials when wood is much cheaper? Why is one man rather than another singled out and appointed as production manager of a large industry?—it is usually because he *has something* that the other fellow does not have. A similar explanation might be given for plastics usage.

Properties.—The previous statements suggest an analysis of the properties of synthetic resinoids to see what they will do. Fabricators are interested in one type of information and consumers are interested in another. Molders of plastics are interested in the general molding qualities of the compound and in pressures and temperatures necessary for both compression and injection molding. A consumer may require such items of information as the following: specific gravity, strength (both tensile and compressive), surface hardness, thermal conductivity, heat resistance, softening point, dielectric strength, water absorption, burning rate, effect of age, effect of sunlight, effect of acids and alkalies, effect of solvents, machinability, clarity, and color range.

Many of the properties of specific plastics were listed under "Kinds of Plastics" in Chapter 2. Uses to which these particular properties of the plastics are adapted were outlined also. The range of a few outstanding properties are mentioned here. Perhaps the lightest in weight is ethylcellulose with a specific gravity of 1.14, while phenolic molding compound is the heaviest with a specific gravity of 1.25 to 2.09. Color possibilities in plastics run from the blacks and browns through an unlimited range, varying with individual types. Clarity

runs from opaque phenolic molding compounds to the methyl methacrylate resinoids which have a light transmission of 90-92 per cent. Only the styrene and vinyl plastics are unaffected by strong acids. Strong alkalies do not affect nylon, styrene, vinyl, ethylcellulose, and refractory-type, cold-molded materials. Shellac and pyroxylin are susceptible to rapid burning. Vinyl and styrene compounds and shellac have a zero water absorption rate after twenty-four hours of immersion. The other plastics have a low rate of absorption, with the exception of casein and nylon, which rate as *high absorption.*



(Courtesy of Röhm and Hass Co., Inc.)

Figure 65. "Plexiglas" enclosures used on Martin bombers.

USES.—A current use for plastics is in aircraft construction like that in Figure 65. The rear gunner of Martin bombers is also protected by "Plexiglas" enclosures which can be revolved mechanically to train multiple machine guns at planes attacking from the rear. Resembling the dome of an astronomical observatory, the enclosure is designed to permit the swinging of the guns. Formerly gunners were unprotected, but high-altitude flying at five or six miles a minute necessitated the "Plexiglas" enclosures. These higher speeds also required that the enclosures be power-operated so that guns could be accurately aimed in the terrific air-stream flowing past the fuselage. While plastics have found their way into practically every field of

manufacture, eleven fields have been selected and ten applications of plastics mentioned here for each field.

Architecture
- ceilings
- decorative trim
- door knobs
- escutcheons
- wainscoting
- window stools
- wall paneling
- drain boards
- panel binder
- lighting fixtures

Automobile
- steering wheels
- horn buttons
- instrument panels
- control knobs and dials
- lens parts
- door handles
- escutcheons
- distributor parts
- gears
- interior trim

Aviation
- propellers
- fuselages
- gears
- instrument cases
- instrument panels
- bearings
- cowls
- nose sections
- windshields
- bomb doors

Costume accessories
- lighters
- buttons and buckles
- hair ornaments
- beads
- bracelets
- brush parts
- umbrellas
- rain coats
- compacts
- ear rings

Dental and Medical
- plates
- teeth
- sutures
- throat lights
- diathermizers
- surgical instruments
- dental instruments
- chin supports
- filter fabric
- containers

Electrical
- commutator
- condenser
- insulation
- coil forms
- magnets
- telegraph parts
- telephone parts
- terminal blocks
- transformer parts
- voltage regulators

Household Equipment
- handles and knobs
- mixer housings
- sweeper housings
- furniture
- table tops
- icebox covers
- bowls
- clock cases
- ash trays
- picture frames

Industrial
- safety goggles
- machine guards
- signal parts
- switch parts
- bearings
- bobbins
- machine parts
- enamels
- sprinkler heads
- brake couplings

Radio
- knobs
- tube bases
- insulating wire
- cabinets
- bezels
- rectifiers
- antenna housings
- high-frequency parts
- coil insulation
- handles

Sporting Goods
- fishing reels
- lures
- bird calls
- billiard balls
- gun stocks
- shuffleboard parts
- golf tees
- ping pong balls
- whistles
- skittle balls

Textiles
- shower curtains
- hose
- dress goods
- hats
- bead cord
- sewing thread
- bathing suits
- wool blends
- upholstery fabrics
- felt blends

School Laboratories.—An application of plastics occurring within the past five years is its use in public school laboratories. Plastics is taking its place along with wood, metal, ceramics, and textiles, as one of the important media of practical arts. Pupils in art and industrial-arts departments are attracted to the material because of its interesting colors and attractive permanent finish. Its extensive use has been retarded by the relatively high cost of material.

While the most work has been done with cast resinoids, molding compounds, laminated forms, and sliced thermoplastic sheets will find a place in a school program as soon as instructors and administrators have had an opportunity to explore their possibilities. If the plastics industry is to continue its growth, an intelligent personnel is essential. A pupil who finishes his public-school work has a right to know something of this industry just as he has a right to know something of the metal industries. If this opportunity for exploration is not provided by public education, how will a youth determine an aptitude for or develop an interest in plastics?

Cast and laminated plastics lend themselves more readily to school use than do the other types, for most of the necessary tool equipment is available in the industrial laboratories. While it may be necessary for small school systems to limit work in plastics to laminated and cast materials, there is no reason why larger systems cannot provide their pupils with molding equipment. Molding technique can be learned by using small laboratory presses with electric heating plates, such as the press in Figure 99. Stock molds can be purchased from mold equipment manufacturers or can be made in the metals laboratory. Molding compounds may be purchased and colored as desired. The 20,000 pounds of pressure is ample for small molding jobs, either with thermosetting or with thermoplastic compounds. The molding division of the industry is much larger than the cast division, so why not introduce our youth to this type of fabrication?

Laminated sheets can be used quite easily with the equipment in a woodworking laboratory. All equipment for veneering is available. Models and other objects can be fabricated from thicker laminated sheets. Laminated rods and tubes may be introduced to electrical

laboratories, because the electrical and radio fields use large quantities of these forms of plastics.

The acetate and nitrate sheets can be worked in with the other plastics forms and used for overlaying or other decorative treatment. These sheets can also be used for veneers on curved surfaces. They are easily cut to outline, and little or no edge smoothing is necessary. Thermoplastic sheets sliced thicker have a very interesting application in laboratory use—that of swaging. A sheet of the plastics is heated and, when sufficiently soft, pressed between suitable dies and allowed to cool. Card trays, ash trays, shallow-profile bowls, and costume jewelry can be shaped in this manner. These sheets may also be shaped while cold in much the same manner as cast resinoids.

To a home craftsman, all of the opportunities for shaping plastics materials are open, with the possible exception of molding. Many leisure hours can be spent on plastics as a hobby, and earnest efforts will be rewarded with articles of lasting beauty.

Chapter 4

Tools, Equipment, and Supplies

SYNTHETIC RESINOIDS are unique in respect to the equipment necessary for working them, for few special tools are necessary. When a craftsman wishes to use a new material which has come upon the market or wishes to add an old material to his supply of raw materials, the problem of additional equipment too often prohibits the undertaking. Plastics may be worked satisfactorily with many common woodworking and metal-working tools. One should not gather from this statement that the same procedure followed in fabricating wood and metal can be applied to plastics—it cannot. But the operations are problems for another chapter.

Since many of the common tools usually found in a craft laboratory may be used, it is possible to add the synthetic resinoid as another medium with little additional expense. In this manner, the range of the work may be broadened considerably. A woodworking or metals laboratory may be adapted to plastics with the addition of a few tools.

Mindful of the old adage that "a workman is known by his tools," it is hoped that the tools, equipment, and supplies illustrated or mentioned in this chapter may help the beginner in his selection of equipment and that the workman in the laboratory may adapt and use the tools at hand to a greater advantage. A skillful worker will soon learn to fashion holding devices, such as arbors and jigs, for the problem at hand.

SELECTING DESIRABLE TOOLS

In a general way, it may be said that any tool which will cut either metal or wood will cut plastics. Considerable change in the speed of operation, depth of cut, and the shape of the cutting tool, however, may be necessary. A number of tools which have proved their usefulness in shaping articles from plastics are listed later in

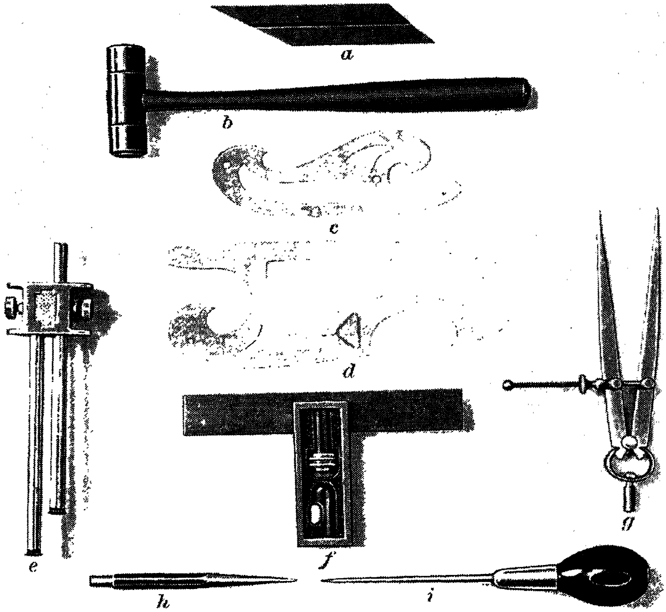


Figure 66. Laying-out tools: (a) miter blade, (b) soft-face hammer (c) irregular curve, (d) irregular curve, (e) mortise gauge, (f) square, (g) dividers, (h) prick punch, (i) scratch awl, (j) scriber, (k) rule.

this chapter and in Appendix B. Machines operate efficiently on these synthetic solids. They are mentioned because they render possible many operations otherwise impossible in addition to making the work easier.

A wooden chair may be made entirely with hand tools, but machinery makes possible the doing of the work more quickly, more easily, and more accurately. In a like manner, a candlestick can be made from cast resinoids with hand tools, but a disc sander, a jig saw, a polishing head, and perhaps a lathe, will result in a smoother and more attractive product.

LAYING-OUT TOOLS.—A person about to begin work on a problem usually finds that some laying-out tools are among the first required. A number of laying-out tools are illustrated in Figure 66. In most cases, only a part of this group would be used to lay off a problem.

Miter Blade.—Aside from its regular use in the square, a miter blade will be found very efficient when used as a straightedge for scribing.

Soft-Face Hammer.—Soft-face hammers are recommended for use with plastics on account of their resiliency. There is less tendency to chip the work when they are used with a prick punch in locating positions for dividers.

Irregular Curves.—Irregular curves are quite useful in laying out work, since the trend in modern design is toward elliptical forms rather than the circle arc.

Mortise Gauge.—The mortise gauge is a time-saving device, since two measurements may be kept for alternate use. A fine sharp point is necessary on the gauge when used on plastics. The wheel end is not satisfactory.

Square.—A combination try and miter square with miter-blade attachments offers a variety of uses over the common try square.

Dividers.—Laying out problems often necessitates the use of dividers. Dividers with sharp, hardened points are necessary for layout work on plastics.

Prick Punch.—After locating the centers for holes to be drilled, by the use of center lines, a prick punch (used lightly) will aid in accurate starting of the drill or in providing a point for setting dividers.

Scratch Awl.—Pencils may be used on unfinished plastics, but the mark is only temporary. A scratch awl is much better for marking positions, on both finished and unfinished plastics. No scratched line which will not be covered or cut off should be made, however.

Scriber.—No plastics laboratory is complete without a good scriber—the "pencil" for plastics. Care should be taken not to scribe unnecessary lines or run beyond a point where a cut is to be made. These lines are hard to remove and require special work in the finishing processes.

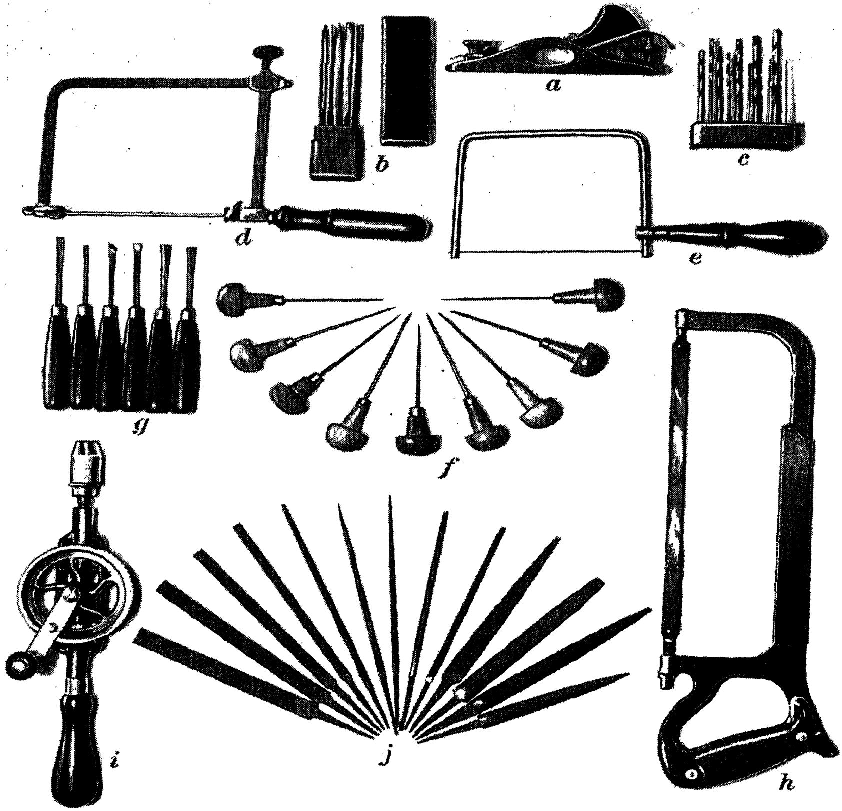


Figure 67. Hand shaping tools: (a) block plane, (b) needle files, (c) twist drills, (d) jeweler's saw, (e) coping saw, (f) gravers, (g) carving set, (h) hack saw, (i) hand drill, (j) files.

Rule.—Flat steel rules are recommended for plastics, since almost all lay-out work is accomplished with scribers or scratch awls.

HAND SHAPING TOOLS.—A number of hand shaping tools (suggestions of a home laboratory) are illustrated in Figure 67. All of these tools are standard equipment and generally found in the small as well as the larger laboratories.

Block Plane.—Edges and flat areas may be reduced to a very smooth surface by the use of a block plane. The blade must be sharp,

well honed, and set for a very fine cut in order to function properly. Occasionally a piece of cast resinoid which has been cured too long is found. Another method of smoothing must be found for such pieces, because a plane will only chip the surface.

Needle Files.—Pierced work and intricate designs can be patterned more efficiently with a set of needle files. A set consists of twelve files, no two of which are alike. With the various shapes they provide, practically any area can be surfaced.

Twist Drills.—A small set of twist drills ($\frac{1}{16}''$ to $\frac{1}{4}''$) will serve for a number of purposes. These drills may be used as they come from the factory. For power drilling with larger drills see Figure 112, page 139.

Jeweler's Saw.—Few tools are better adapted to cutting plastics than the jeweler's saw, or fret saw. The danger of chipping is lessened because of the very fine teeth available in these blades. They are excellent for thin sheet plastics.

Coping Saw.—For rougher cutting and thick sheet plastics, the coping saw may be used. Regular pin-end blades are standard. They are generally found in a woodworking laboratory.

Engraving.—For best results, engraving tools should be ground so that the cutting face, when a tool is held in cutting position, makes an angle of approximately 90 degrees with the working surface. Thin shaving cuts are better than deep ones.

Carving.—Regular carving tools are satisfactory when used for light, paring cuts. There is a tendency to chip and leave a rough surface if deep cuts are made. Edges which are too thin are largely responsible for this condition. Carving tools made from old files often work better than regular tools.

Hack Saw.—Hack saws used for cutting cast resinoids should have medium fine teeth. A blade with exceptionally fine teeth will "clog" and slow down the cutting operation. They are best adapted to rods, tubes, and cylinders.

Hand Drill.—Wheel-type hand drills for use on wood or metal can be used for plastics. Automatic "push" drills are not recommended, since the pressure required to run them will cause a breakthrough before the drill reaches the opposite side.

Files.—Either metal-working or woodworking files may be used for shaping operation. Cabinet files are fast cutting, but leave a rougher surface than the finer cut files. In Figure 67 several different types of files are illustrated.

Thread Cutting.—Threading with taps and dies is performed on plastics the same as on brass. No lubricant is necessary, but cutting oil will do no harm. Both taps and dies should be cleaned often while using. For tap and drill sizes see Appendix B, Table VI.

Power Tools.—Power tools for a plastics laboratory vary from either the wood or metal standards. In general a lighter type machine is recommended, both for industry and the small laboratory. Several reasons justify this change; the total cost of equipment is lower, operating costs are lower, and, up to the present time, comparatively small, lightweight castings have been made.

Band Saw.—A good standard make of band saw having an adjustable table with a ripping fence and miter-guide attachments is recommended. A 30-inch band saw for continuous work will allow the blade to cool sufficiently before coming into contact with the plastics again. Heat from friction is carried away in this manner and fast cutting is possible. Hardened steel blades with 14 or 15 points per inch are best for smooth cutting. For details see Figure 87, Chapter 5.

Circular Saw.—A circular saw of the type used for cabinet making is desirable. An adjustable table with regular cut-off and ripping attachments is essential. Saws should be thin with only enough set to clear nicely. Only cross-cut and miter saws should be used. Details concerning the number of points per inch and method of sharpening are given in Figure 86, Chapter 5.

Jig Saw.—A jig saw of the motor driven type is preferred. The power head should be adapted to the use of machine files. With this type saw a variety of operations can be carried out. Saw blades for cut-out work should be narrow in order to make abrupt turns. Wide blades are better for ripping and making cuts from rods, tubes, and other small castings.

Machine Lathe.—A small speed lathe for plastics is much preferred to the heavy slower type lathe. Suitable lathes are the 9-inch "Workshop" model and the "Craftsman" metal lathe (see Appendix B).

Sixteen speeds are available on these lathes, ranging from 28 rpm to 3225 rpm. High-speed cutting tools are recommended and should be sharpened to produce long ribbon shavings. Figure 68 illustrates only a few of the many shaping tools and attachments that may be used on these lathes.

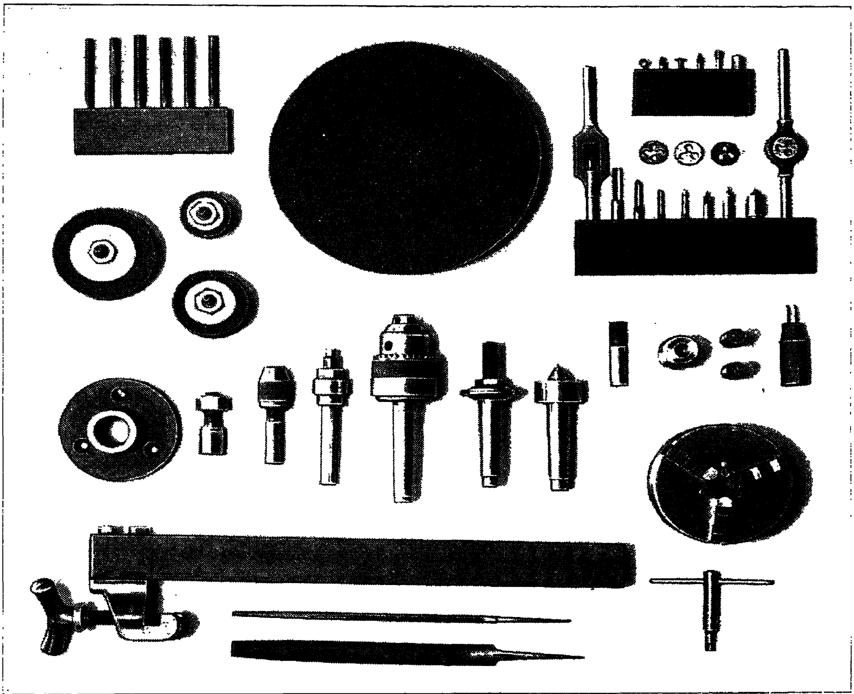
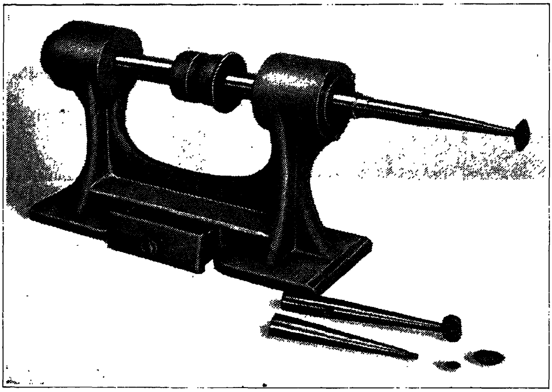


Figure 68. Machine shaping tools and attachments.

Wood Lathe.—A small woodworking lathe with speeds varying from 450 to 6000 rpm is desirable either for production work or for a small laboratory. Most lathes of this type may be equipped with small universal chucks which greatly increases their capacity. Compound rests are also available in many instances. With this equipment and the extra high speeds available, most finishing operations may be completed before removing the work from the lathe.

Drill Press.—Table model drill presses with ½-inch chuck capacity are adequate for all general purposes. A ½ hp, 1750 rpm motor will furnish ample power for multi-speed attachment, which is necessary, if routing and shaping operations are planned. With standard equipment speeds varying from 600 to 5200 rpm, with multi-speed attachments from 200 to 10,000 rpm are available. Sanding drums of small diameters are adapted to drill press operations. For further information on drills and drilling procedures see Chapter 5.



(Courtesy of Lupomatic Tumbling Machine, Co., Inc.)

Figure 69. Carving-head and burrs.

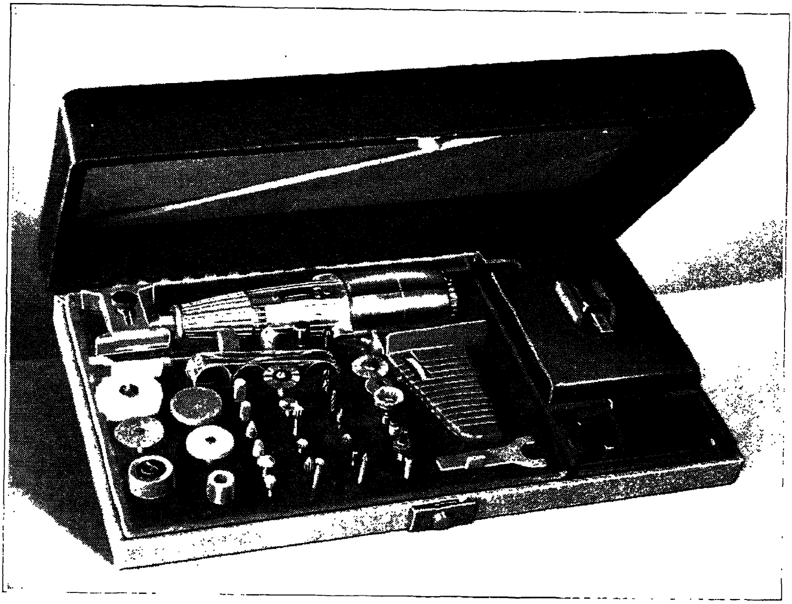
Carving Spindle.—Many types of carving spindles are used, both in factory equipment and in home laboratory equipment. All types from the crude home-made outfit to the more substantial industrial type illustrated in Figure 69, seem to operate successfully.

Recommended spindle speeds for carving burrs ½ inch to 2 inch in diameter, vary from 2200 to 5000 rpm. Rotary steel carving burrs 1 inch in diameter should have 20 to 36 teeth. All burrs used on cast resinoids should have the "hook" removed to prevent digging-in. This is also a safety precaution, keeping in mind that regular shaper bits for wood are too dangerous for use on plastics.

Rotary Tool.—Rotary tools of various makes are on the market. Accessories for these tools are so numerous that the operations are, in most cases, limited only by the ability of the operator.

Rotary tools operate at high speeds, usually from 10,000 to 18,000 rpm. The nature of the work will determine, as in most other cases, the type of tool most fitting.

Grinders.—Since plastics possess a peculiar characteristic for dulling tools faster than either wood or metal, a good grinder is a necessity. These grinders should be equipped with a coarse and medium-fine wheel. Wheels 7 x ¾ inch are practical with a no-load speed of 3600 rpm.



(Courtesy of Sears, Roebuck & Co.)

Figure 70. "Super Crafty" rotary tool.

SELECTING DESIRABLE EQUIPMENT

Equipment, as the term is used here, will include arbors, mandrels, jigs, sanding, and finishing apparatus. Here again usage will govern the selection of suitable equipment.

It is the wish of the authors that from the accompanying illustrations, the craft worker may select an arbor, jig or other piece of equipment that will fulfill his needs, or better still, that these may

suggest to him a better piece of equipment, which he will set about to build.

Arbors.—Many problems turned from plastics require the use of arbors. Wood screws cannot be used in plastics because the material is too dense to admit the threads. When a disc has to be used for lathe work, a peculiar problem presents itself. A method different from that applied either to metal or to wood is required. The discs are often too thin to drill and tap for machine screws. Even though a hole may run clear through the center of a disc, as would

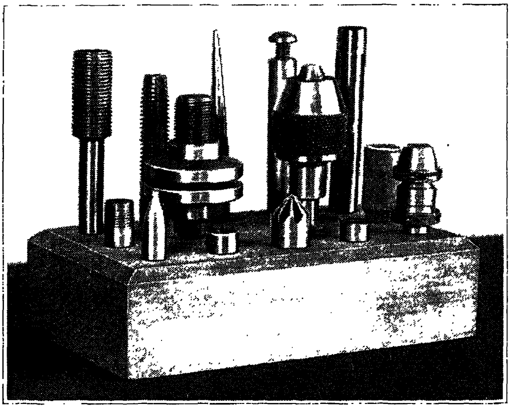


Figure 71. Miscellaneous machine attachments.

be the case in a lamp base, a screw-center face plate is not satisfactory. Small arbors similar to those shown in Figure 72 may be made inexpensively on a machine lathe and will solve the problem of holding for turning all discs having holes in the center.

Turning problems which must be supported entirely at the headstock and which cannot be held in a chuck are of two types: those which have smooth holes in the center, and those which must be threaded in the center either with a hole all the way through or with a hole only part way through. In Figure 72 the arbors *A* and *B* will serve for most discs requiring smooth holes. The two screw sizes are used with a definite purpose in mind. A disc drilled to fit arbor *A* may be tapped for a $\frac{1}{8}''$ pipe after the lathe work is completed, and

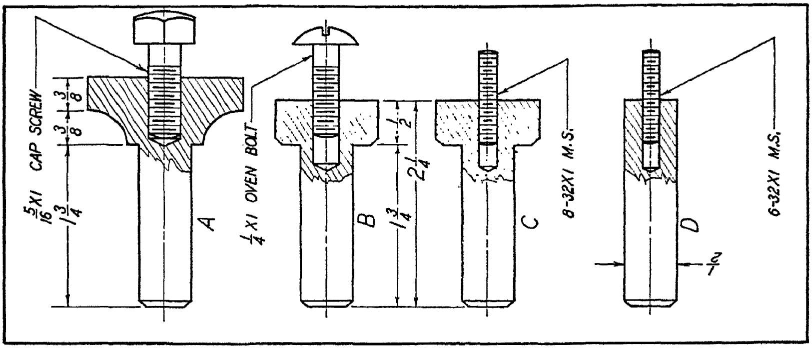


Figure 72. Miscellaneous arbors.

one to fit arbor *B* may be tapped for a $\frac{5}{16}''$ screw without further work on a drill press. If these holes prove to be too large, either arbor *C* or *D* may be used with a round-head machine screw in place of the headless machine screw. The headless screws are provided for holding such pieces as drawer knobs and rosettes which do not have holes showing from the front.

There are a few problems such as buttons and buckles which do not have a hole at the exact center, but which have several holes or cut-out portions in the central part of the disc. Arbors with supports (Figure 73) for these discs are provided for this type of work. Part *A* is made from either brass or cold-rolled steel and is held at the head-

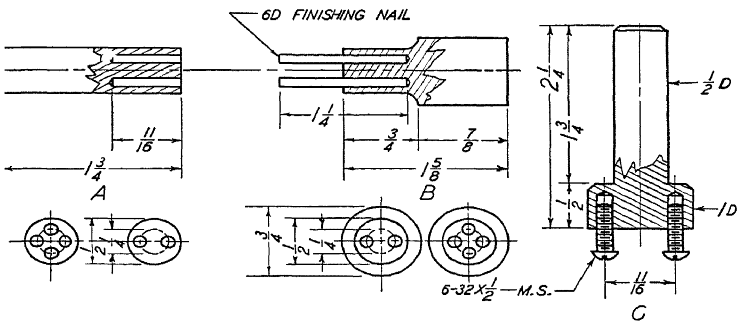


Figure 73. Arbors: (a) Drill chuck arbor, (b) Tail-stock arbor, (c) Slide or buckle arbor.

stock by a lathe chuck. Either two or four holes may be drilled for the supports which run through the holes in the button blank. The tailstock support (*B*) should be made from hardwood with holes drilled to correspond with those in the metal. This support serves two purposes: it provides additional end support, and presses against the button blank to hold it rigid as it turns.

Arbor *C* is designed for buckles and slides. There are at least two cut-outs in most buckles. This condition proves very convenient when designing a holder. The center of the buckle is laid out as it is to be cut. Any diameter is drawn and holes are centered $\frac{11}{32}''$ from the buckle center. At these centers, holes for the machine screws in the arbor are drilled. After the lathe work is completed, the necessary portions are cut out.

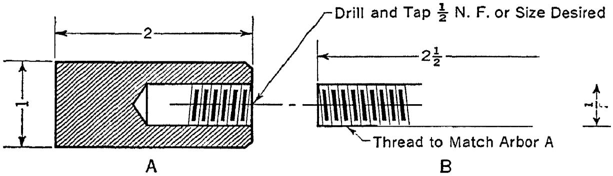


Figure 74. Matched arbors.

Arbors for holding the base and top of salt and pepper sets shown in Figure 152 while being turned and finished present still another problem. A set of matched arbors as shown in Figure 74 can be made on a machine lathe and kept as additional equipment for the laboratory.

Threads are cut on a short rod of cold-rolled steel to match the threads cut in the plastics base. This serves as a holding device for the base. A larger rod of cold-rolled steel is then center-drilled and tapped to match the threaded top which can be held while turning and finishing operations are completed.

Rigid Mandrels.—Plastics cylinders, although they come from the factory rather accurately fashioned, require lathe work for neat fits as well as for additional design. For shaping in a headstock chuck, a special attachment becomes necessary. Simple mandrels similar to those in Figure 75 may be made from wood.

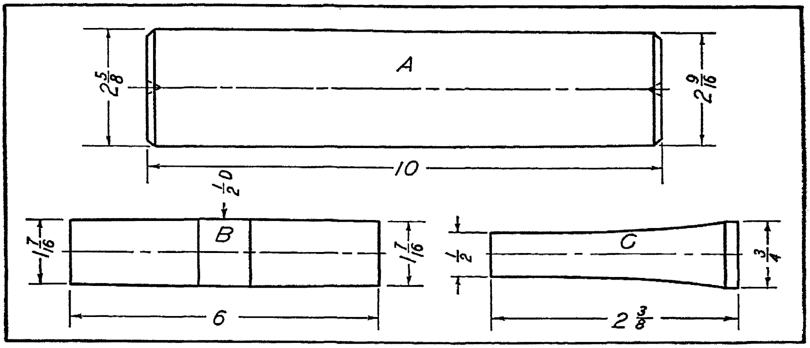


Figure 75. Wooden mandrels: (a) Mandrels for 3″ cylinders, (b) Napkin-ring mandrels, (c) Mandrel for ½″ (I.D.) tubes.

Mandrel *A* is the proper size for a 3″ (O.D) cylinder. Mandrel *B* is designed for turning napkin rings from 2″ cylinders. It is tapered at both ends so that two ring blanks may be turned at one time. The short mandrel *C* is used for providing centers on small lamp parts or other parts with half-inch holes. The mandrels are turned on a lathe and the centers at the ends are carefully retained so that they may be placed again in the lathe.

Adjustable Mandrels.—A mandrel with adjustable cone supports may be made if the necessary tool equipment is available (see Figure 76). Cylinders of plastics ranging in diameter 1⅜″ (O.D) to 3⅝″ (O.D.) are held on center by these cones. This mandrel is adjustable

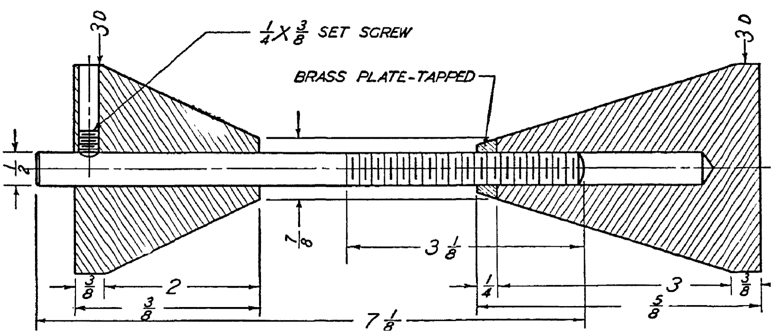


Figure 76. Cone mandrels for plastics cylinders.

for length and will hold a cylinder rigid. A chuck is used to support the left end in place of the live center, while the right end is supported by the dead center. The parts of the jig should be completed with oversize dimensions and placed in the lathe in the manner just indicated before the final cut is made on the cones, to insure greater accuracy. This jig is not recommended except where considerable turning of a variety of sizes is necessary.

Jigs.—Many operations, such as marking, bending, and center-drilling cast resinoids call for the use of jigs. To recommend a jig without a definite problem in mind would be useless. Therefore only a few which may be of general interest are mentioned.

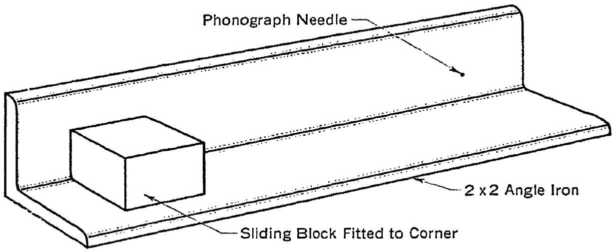


Figure 77. Jig for marking tubes and rods.

Marking.—Accurate marking to length of plastic rods and tubes without some type of holding device offers a difficult problem.

Figure 77 suggests a jig of this type. A section of $2'' \times 2''$ angle iron is used with sliding block of iron fitted squarely in the corner. A phonograph needle is inserted in the back with the point projecting inside. Accurate setting of the block from the needle point can be made with a steel rule. A rod or tube of plastics is then substituted for the rule and rotated lightly against the point. If carefully made, this jig will mark accurately.

Bending Jigs.—In many cases, because of a desire for economy or for some other reason, it happens that a special design cannot be shaped from solid material. It is possible after certain treatment, because of a unique quality which cast resinoids possess, to bend a piece of thin stock to shape. The more difficult bending problems require the use of forms for satisfactory results. Bending operations may be divided into

two groups: the bending of a plastic strip around the outside of a form and clamping it until it has set; and the bending of a part by pressing it between two parts of a form. Examples of these two types of forms are shown in Figures 78 and 79.

A glance at Plate 28, page 218, will be sufficient to see the necessity for a bending jig for this problem. If properly made, this jig may serve the dual purpose of a bending form and of a cementing form. There is a tendency for the outside face of a piece of plastics to resist stretching when a bend is being made. A square end is thus misshapen. Allowance should be made for this condition when bends are made.

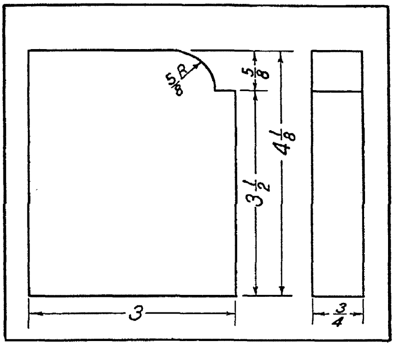


Figure 78. Concave bending form.

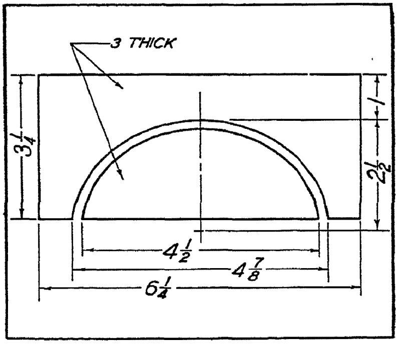


Figure 79. Convex bending form.

Center Drilling.—It frequently happens that other materials such as metals are desirable for ornaments since they provide a variation from the plastics colors. Combinations of brass, pewter, nickel-silver, aluminum, and garaloy with plastics prove very attractive. Balls of brass or aluminum when secured for ornamentation offer a problem of center drilling.

A jig, which will make the task much easier and the finished job more accurate, may be made. Jig *A* holds ½″ balls and Jig *B* holds ¼″ balls. When a ball is clamped in place, the drill is fed through the hole in the sleeve and is automatically centered.

Buffing Jig.—A holding device is sometimes helpful where a number of duplicate parts have to be surfaced. The holder shown in Figure 81 will speed up and improve the quality of work on certain problems.

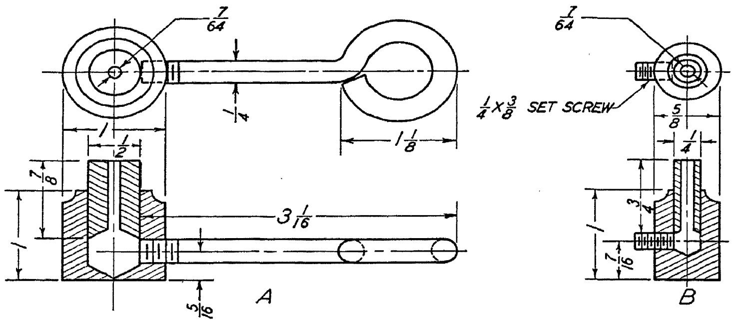


Figure 80. Drilling jigs: (a) Centering and drilling jig for ½″ spheres, (b) Centering and drilling jig for ¼″ spheres.

Sanding Equipment.

Disc Sander.—A sander equipped with an abrasive disc 8 to 12 inches in diameter is a very valuable piece of equipment in the plastics laboratory. Figure 82 illustrates a sander of this type with a dust-collecting bag attached. Such a dust collector will help in controlling the annoying odor given off during sanding operations.

Belt Sanders.—Figure 83 shows a belt sander being used on plastics in a commercial laboratory. A dust collector is in use on the machine. At present, combination belt and disc sanders are available. Care should be taken in selecting sanders to see that the motor is amply large. Motors from ⅓ hp to ¾ hp are used on this type sander, depending on the size of belt and disc used.

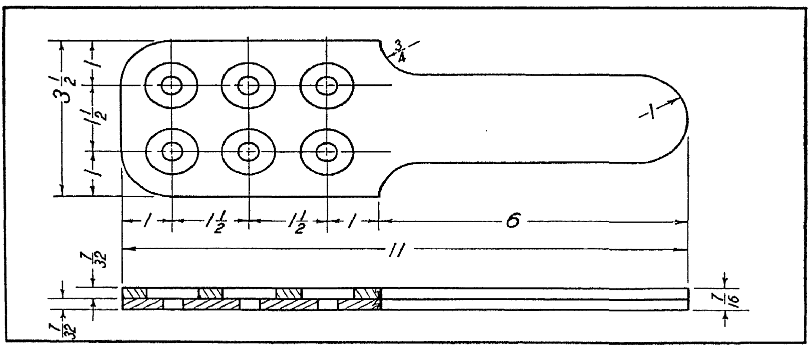
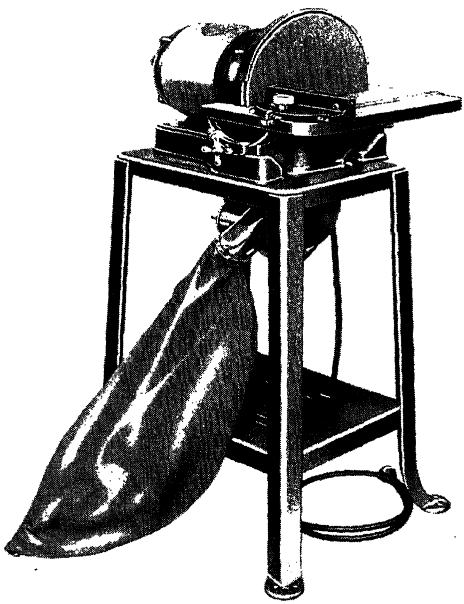


Figure 81. Holder for checker discs.



(Courtesy of the Delta Mfg. Co.)

Figure 82. Disc sander with dust collector.

Abrasives.—Sandpaper on power wheels is not recommended. Garnet electro-coated papers will speed up work and last much longer. The number of abrasive paper used depends on the type of work being done. For general use, a No. 1 to 2 abrasive paper is used. Open-grained abrasives as fine as No. $\frac{1}{2}$ may be used, if care is taken not to burn the work.

Finishing Equipment.

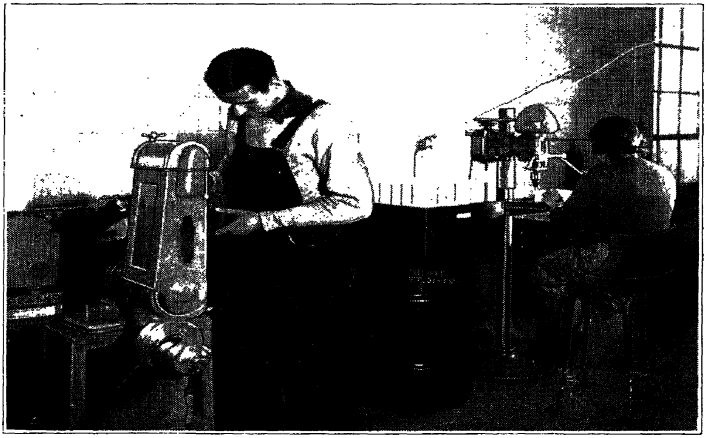
Since the finishing operations of cast resinoids are explained in Chapter 6, only a list of equipment will be given here. Selections may be made and names of the companies supplying this equipment obtained from Appendix B.

Apparatus.

(*a*) Tumbling barrels
(*b*) Buffing heads
(*c*) Files
(*d*) Buffing wheels

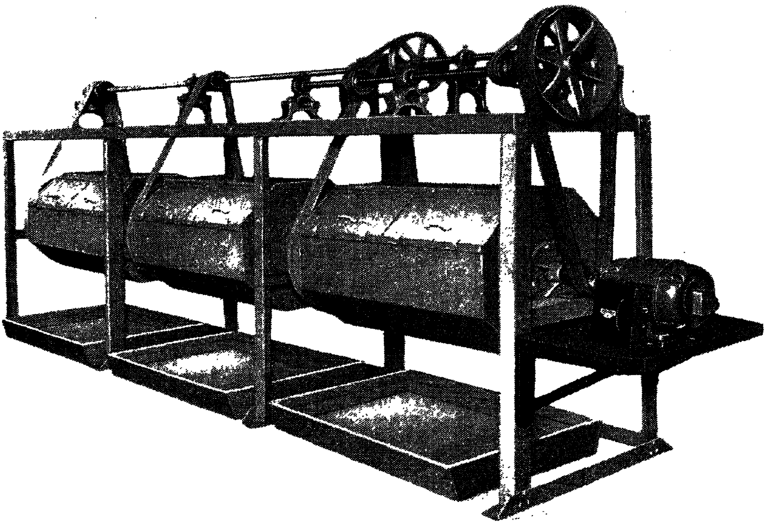
Abrasives.

See Table II, Chapter 6.
Operations and abrasives used finishing plastics.



(Courtesy of the Delta Mfg. Co.)

Figure 83. Belt sander in use in the Eclipse Molded Products Co.



(Courtesy of Lupomatic Tumbling Machine Co., Inc.)

Figure 84. Battery of tumbling barrels.

SUPPLIES

Every laboratory should have some stock of supplies. The list of supplies given here is only general, and no attempt is made to fit the supplies to any particular laboratory. In general the supplies will consist of plastics, abrasives, saw blades, cements, fastening devices, and metal findings. For names of distributors handling these materials see Appendix B—"Supplies."

Plastics

A. Sheets (12 × 24)

$\frac{1}{4}$

$\frac{3}{4}$ inch in thickness

B. Round rods (stock molds)

$\frac{1}{4}$
$\frac{3}{8}$
$\frac{1}{2}$

1
$1\frac{1}{4}$
$1\frac{1}{2}$ inch in diameter

C. Square rods (stock molds)

$\frac{5}{8}$
$\frac{3}{4}$
1
$1\frac{1}{2}$
2

D. Cylinders (stock mold)
1″ O.D. × $\frac{1}{2}$″ I.D.
$1\frac{3}{8}$″ O.D. × 1″ I.D.
2″ O.D. × $1\frac{1}{2}$″ I.D.
3″ O.D. × $2\frac{5}{8}$″ I.D.

E. Hexagon rods (stock molds)
$\frac{1}{2}$
$1\frac{1}{4}$

F. Scalloped rods (stock molds)
$1\frac{1}{8}$

G. Special castings
Ring stock
Animal shapes
Buckle stock
Anchor stock
Dress clip stock

H. Cellulose acetate sheets (20 × 50)
.010
.015
.020
.030 inch in thickness

I. Laminated sheets
Real-wood $\frac{1}{16}$″ in thickness
Plain colors $\frac{1}{16}$″ in thickness

Abrasives
No. 2 electro-coated garnet paper
No. $1\frac{1}{2}$ electro-coated garnet paper
No. 1 electro-coated garnet paper
No. $\frac{1}{2}$ electro-coated garnet paper
No. 0 waterproof garnet paper
No. 3-0 waterproof garnet paper
No. 7-0 waterproof garnet paper
FF pumice stone
Lea Compound Grade "C" or Grade "S"
Learok buffing compound Grade No. 119
Rotten stone
Learok buffing compound Grade 304B
Learok buffing compound Grade 746

Saw blades (assorted sizes)
- Jig saw
- Coping saw
- Fret saw
- Jeweler's saw

Fastening devices
- A. Machine screws
  - 6-32 × $\frac{3}{4}''$ flat head
  - 6-32 × 1″ oval head
  - 8-32 × 1″ round head
- B. Drive screws
  - No. 00 × $\frac{1}{8}$ round head
  - No. 00 × $\frac{3}{16}$ round head
  - No. 00 × $\frac{1}{4}$ round head
  - No. 0 × $\frac{5}{16}$ round head
  - No. 6 × $\frac{3}{8}$ flat head
- C. Self-tapping screws
  - No. 2 × $\frac{3}{8}$ flat head
  - No. 4 × $\frac{5}{8}$ flat head

Metal Findings
- 1″ bar pins (for drive screws)
- $1\frac{1}{2}''$ bar pins (for drive screws)
- Dress clasps
- Spring clasps
- Buckle catches
- Hinges
- Ear ring mounting

Adhesives
- Acetate cement
- Opaque plastics cement
- Transparent cement
- Accelerator
- Rubber cement

Miscellaneous supplies
- Glass mixing rod and plate
- Dilute hydrochloric acid
- Ethyl alcohol
- Cutting oil

Chapter 5

Forming and Shaping Operations

One may well spend time considering the nature of the particular synthetic solid with which he expects to work. What may one expect the material to do? What properties does the material possess that will make this result possible? What is the range of operations which the equipment at hand will permit? Is the design in keeping with the material, or is it reminiscent of some wood or metal problem? If answers to these questions are sought and found, the worker is ready to proceed in the creation of something worth while from a most interesting material.

Cast resinoids may be described as synthetic materials possessing the hardness and rigidity of metals, the resiliency of wood, and the inherent beauty of jade or amber. There is no filler in cast resinoids as in the case of laminated or molded plastics. There should be no abrasive material, therefore, in the resinoid; yet a peculiar property causes it to dull cutting edges on machine tools quicker than steel. A sharp tool must be used. Tools which will still cut steel very acceptably cause a plastic rod to "pile up" on itself as a cutting rolls off in chip form. For smooth cuts, then, tools must be ground frequently and honed still more frequently.

The potential energy of a moving tool or a piece of material turning against a rigid tool is transformed into heat. Much of the heat at a cutting edge is absorbed by the material and causes it to expand. An unusual amount of heat causes the plastics to give off a pungent odor which is not altogether pleasant to one's nose and eyes. Dust from a sander or saw carries the same odor. While this emission is not harmful as far as present information goes, it is unpleasant and should be avoided as far as possible.

SAWING

Cast resinoids may be cut with practically any type of saw which will cut wood or metal. Many saws, however, are not designed for effi-

cient cutting. All woodworking saws and most metal-working saws have a very definite positive rake (see Figure 86). These saws work very well on the material for which they are intended, but they produce a rough cut and chip the surface opposite the operator when they are used on plastics. "Celluloid" (cellulose nitrate) and "Lumarith" (cellulose acetate) in stock sizes, from .003 to .030 inches in thickness, may be cut with sharp linoleum-block knife, shears, or tin snips. For purposes of discussion, saws are divided into two groups: hand saws and power saws.

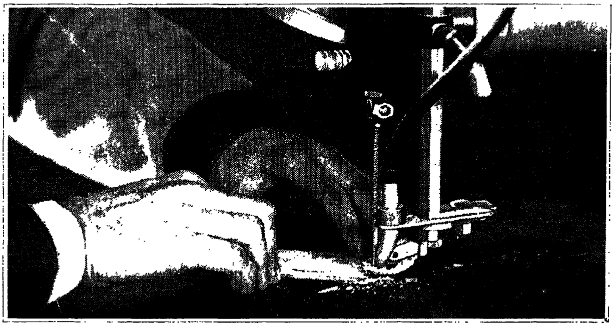


Figure 85. Sawing outline of overlay design on jig saw.

All saws should be held rigid while operating. A cramped blade will invariably produce a chipped surface. The same principle holds true of a piece to be cut. When cutting is done by hand, the work should be clamped firmly in a vise or held rigidly by hand. Do not feed too rapidly—let the saw make its own path without forcing. In sawing rods and tubes of acetate and vinyl plastics, friction against the sides of the saw must be reduced to a minimum. If this is not done, the heat produced may cause the material to soften and "gum-up" the saw.

Hand Sawing.—Hand saws which are suitable for use on plastics include the coping, fret, and finer-toothed back saws. Rip saws and large-toothed cross-cut saws are out of the question, either because there is too much rake or because the teeth are too coarse. The teeth in an averge pin-end coping-saw blade have too much rake, but a coping saw may be used for cutting heavier pieces. Since thinner

sheets ($\frac{1}{8}''$-$\frac{3}{16}''$) require finer teeth on saw blades, a loop-end coping saw is more satisfactory.

A fret saw or a jeweler's saw is much more satisfactory for hand work, since a greater selection of tooth sizes is available. The blade used may be adjusted to the material that is to be cut not only as to thickness but as to intricacy of design.

Back saws are more suitable than cross-cut saws because the teeth and blade are finer. A back saw with teeth coarser than 12 or 14 points to the inch should not be used. A miter box is especially useful in cutting rods and tubes. If care is taken, chipping at the opposite edge and bottom can be avoided. A miter box makes possible smoother and more accurate cuts than are otherwise possible. In no event should a piece of stock be permitted to twist on the saw. Square or rectangular pieces should rest on a flat piece of scrap wood placed over the miter-box bed and moved to a new position for each cut made. If the saw can drop into an old kerf in the bed, the stock will usually chip. Chipping on cylinders and rods may be prevented by revolving the piece as it is cut. If the proper precautions are taken, a piece of plastics will come from the miter box ready for sanding.

Power Sawing.—Fine-toothed saws of high-speed alloy steels, operating at high speeds, produce the most satisfactory results on production work. Quite often in the small laboratory there is nothing that can be done about the kind of steel in the saw blade, for the blades on hand must be used. The problem of adapting common saws for use would seem more practical, therefore, than the purchase of special saws.

Circular rip saws or combination saws which have deep gullets are not suitable because there is too much positive rake. Cross-cutting or miter saws which have about nine teeth to the inch and which are from six to ten inches in diameter produce good work. These blades should have some set, even though they are hollow-ground. Operating speeds ranging from 1800 to 2500 rpm may be used. Figure 86 shows how a fine-toothed rip or combination saw may be adapted to cutting plastics. In no case should a piece of stock be allowed to bind when it is being cut. Best results are obtained when the points of the teeth in use project through the work.

Band saws are the most practical saws for getting out stock material. By the use of both the ripping fence and cut-off or miter gauge, thin slices of ring stock, animal designs, rods, tubes, cylinders, and special castings may be cut rapidly and accurately. For smooth cuts the saw should have very little set and should be sharpened with little or no positive rake, as illustrated in Figure 87. Saws having less than five and one-half or six points per inch are not satisfactory for cutting plastics because of chipping. Plastics in sheet form $\frac{1}{8}''$ thick and up) may also be cut by this method. If irregular curves are to be cut, a saw $\frac{3}{16}''$, or not over $\frac{1}{4}''$ in width should be used. In cutting

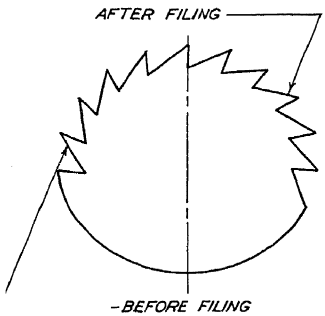


Figure 86. Correct shape for circular-saw teeth.

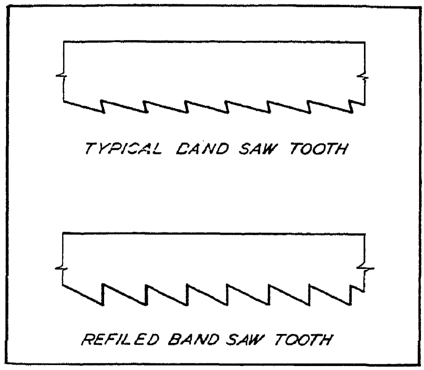


Figure 87. Correct shape for band-saw teeth.

special castings with thin sharp edges (a Scotty dog or duck), feed the work slowly as the saw enters and again as it leaves these particular points. Surfaces cut in this manner should compare with those made in a miter box. The hook or positive rake on a new band-saw blade should be removed when it is refiled if smooth cutting is desired.

The jig saw is the most adaptable power saw in the small workshop. Like a fret saw, there is a large variety of blades from which to choose. Fine wood blades, fret blades, and metal blades are suitable. Figure 88 illustrates the use of a jig saw for sawing thin sections from cast forms.

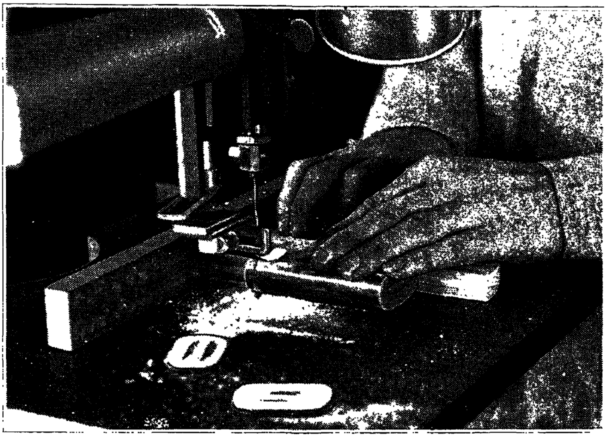


Figure 88. Sawing sections from belt buckle on power jig saw.

The L-shaped jig is made of wood thinner than the stock to be cut. By placing the plastics stock along-side the base and the upright of the L against the ripping fence, thin sections may be sawed. The ripping fence is kept away from the saw guide and the hold-down by the use of this jig, but it still serves its purpose. The machine should be maintained so that there is as little vibration as possible. The hold-down should be kept adjusted close to the work in order to mini-

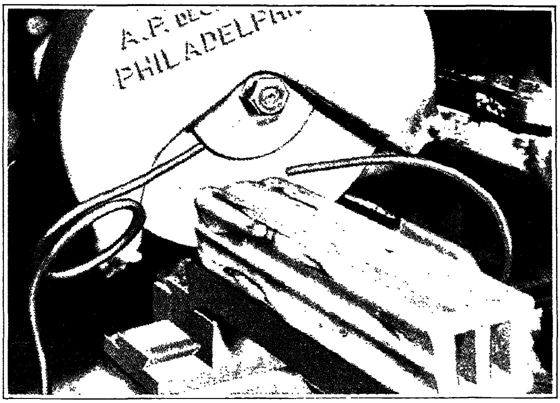


Figure 89. Power cutting wheel.

mize vibration. Dull blades should be disposed of before they produce rough cuts and before the material starts to bind on the blades. A jig saw is almost indispensable in a school laboratory. Less skill is required for successful operation than is required for operating a fret saw, and many more intricate designs are possible.

When a number of parts are required, such as buckles, buttons, or lamp parts, and smooth edges are desirable, a cutting wheel of silicon carbide bonded with Bakelite is the most economical method of cutting. One of these discs may be secured for a power saw (if the saw is properly guarded) and used dry if the stock is fed slowly. A cutting wheel operated with a heavy motor and cooled with water (Figure 89) is used by production plants for work of this nature.

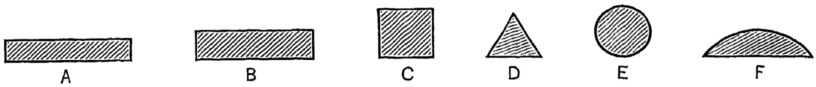


Figure 90. Cross-sections of common file shapes.

FILING

Hand Filing.—Hand files are often necessary to complete forming and shaping operations. Special shapes and cut-outs also require filing. Ordinary cabinet and metal files may be used for this work. Cross-sections of files generally found in the shop laboratory are shown in Figure 90.

Machine Filing.—Jig saws equipped to hold machine files will eliminate much tedious hand filing. Special jig saw files (Appendix B) are available in the following shapes; 3-square, round, crochet, pillar, square, and half-round.

Flutes, as illustrated in Figure 91, and other special cuts may be made with an accuracy difficult to obtain by hand.

SANDING

Hand Sanding.—Sanding by hand may be substituted for filing operations, if the regular filing equipment is not available. With very little expense, several small blocks of wood, to be used as sanders, can be made and partly covered with electro-coated abrasives. A set of sanders may be made from 6-inch lengths of dowel rods, ranging

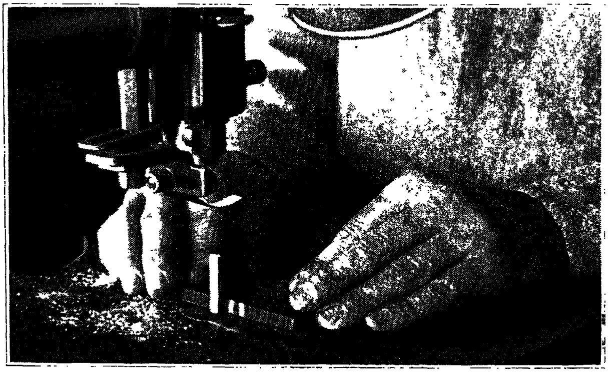


Figure 91. Machine filing of flutes.

in size from $\frac{3}{16}''$ to $\frac{3}{4}''$. These sanders will be found useful in any laboratory. A two-inch handle should be left uncovered to allow for four inches of abrasive on the other end. In a similar way, other sanders may be made to fit special shapes. This equipment is particularly suited to the sanding of rings made of acetate plastics.

Power Sanding.—A disc sander with table and miter fence attachments will find as many uses in a plastics laboratory as in the general woodworking laboratory, if not more. Curvilinear and rectilinear forms may be quickly and accurately shaped by using discs covered with No. 1 or No. 2 electro-coated garnet paper. Bevels and chamfers may be produced the same as on woods. Finer abrasives may be used for more accurate work, but they will fill up and burn the work more rapidly. Belt sanders may be used in the same general way.

GRINDING

Power Grinders.—Grinding wheels were among the first forms of power equipment to be used on cast resinoid plastics when it was introduced in our school laboratories. Many other machines have been adapted to shaping plastics; hence grinding wheels are used extensively for cutting off flashes and sprues on molded parts. Coarse-grit wheels are necessarily used, since the finer-grained wheels will clog quickly and burn the material. Small grinding wheels from 4″ to 8″ in diameter and $\frac{1}{2}''$ or less in thickness, with the arrises removed,

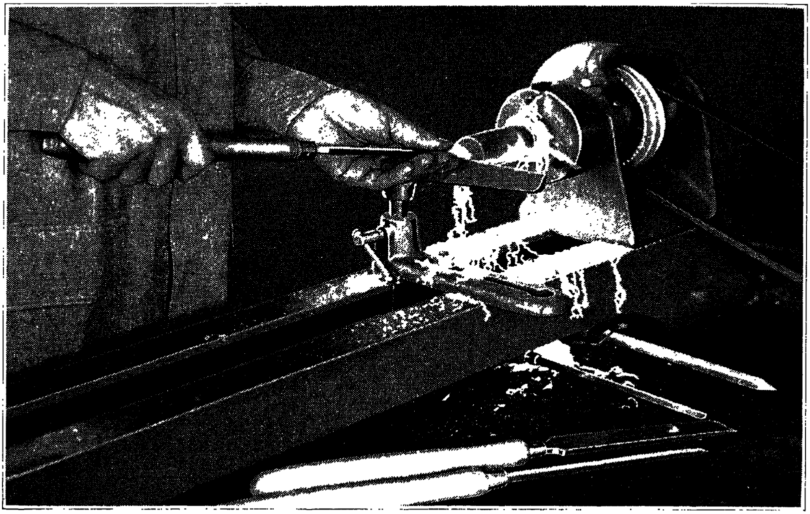


Figure 92. Turning a rod of transparent cast phenolic on a "Craftsman" lathe.

are ideal for shaping concave surfaces found on rings and many other problems. Speeds may vary from 1800 to 3600 rpm depending on the size and grit of the wheel.

TURNING

Turning of cast resinoids may be done successfully either on a wood lathe or on a machine lathe. Each method has distinct advantages over the other. If feasible, each type of lathe should be represented in the laboratory. If this equipment is not practicable, a happy solution of the problem is a machine lathe with woodworking attachments, or a wood lathe with machine attachments. Turning problems related to the lathes are treated separately.

Wood Lathe.—Mounting plastic rods for turning is not the simplest problem of turning, but it must be faced. Because of the nature of the material, it is impossible to drive or force a live center into the end of a rod. Centering is more commonly done by following the methods used on metal. A live center, however, may be used by cutting a groove across the end of a rod to provide for the spurs.

Another method of mounting involves an arbor held in a chuck in place of the live center. The end of the rod is centered, drilled, and tapped for a machine screw. Use a good lubricant such as red lead at the center to prevent excess friction—heat causes difficulties. Mandrels and cone centers of wood are used for mounting cylinders.

Face-plate mounting is accomplished in a number of ways. Discs $\frac{3}{8}''$ or more in thickness may be mounted by drilling and tapping for machine screws. Self-tapping screws may also be used. Thinner discs may be mounted as shown in Figure 93. The waste corners provide a space for wood screws. Discs are turned down to paper thickness before the disc is removed from the lathe. A piece of wood should be mounted directly on the face plate. A square sheet mounted to the wood is easier because there is a greater space for screws. Holes in a face plate will rarely occur in the proper location for mounting thin pieces.

Arbors provide the easiest method of mounting plastics and are most widely used. They are adaptable, however, only where a hole in at least one side of the material is permissible. Figure 94 illustrates a few of the many arbors that may be used on the wood lathe.

At times a hole can be enlarged for some other purpose or an inlay can be used to advantage for filling the hole made for the arbor. Whenever this expedient is possible, the task of mounting on a face plate is eliminated.

Until recently, only machine lathes were equipped with 3-jaw universal chucks. Now it is possible to purchase this type chuck for most woodworking lathes in addition to the regular $\frac{1}{2}''$ chuck. In general this makes the equipment for the lathes interchangeable. The number of operations is also increased. A block of wood mounted on a face plate, and turned as a friction chuck, is recommended for turning bracelets or other circles, where it is necessary to work on the entire outer surface. A slight taper will increase the usefulness of the chuck.

With the exception of gouges, all wood-turning tools are used on cast resinoids. It is possible to use a gouge, but other tools are more easily used. A scraping cut is recommended, although a shearing cut is possible at times. Regardless of the description of the cut, the cut

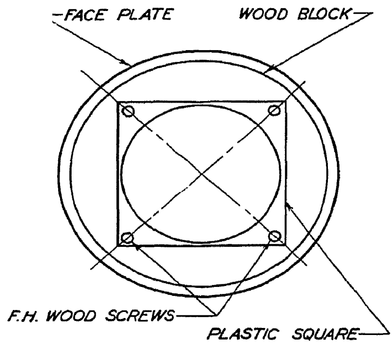


Figure 93. Face-plate mounting for sheet plastics.

material or shavings should come from the tool like ribbons—never like powder or small chips. Be assured that there is something wrong if the latter type of cutting appears. It may be in the shape of the tool, in the angle at which it is held, or in the cutting edge.

Always keep keen edges on turning tools. A tool which will not cut cast resinoids will still cut woods in an acceptable manner. Keep an oilstone handy at the lathe. The handles of the tools should be higher than the cutting edge when turning, to provide a negative or zero rake. In this position, the tool rest must be adjusted so that the

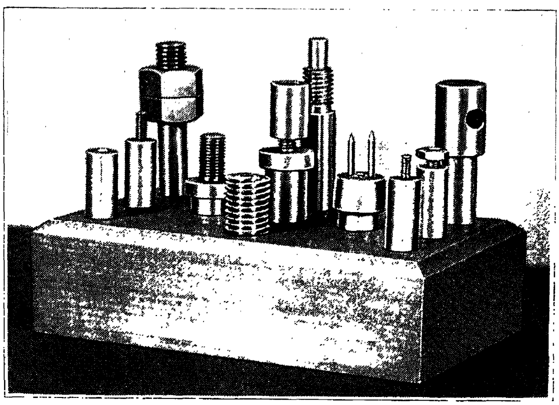


Figure 94. Arbors for use on wood and metal lathes.

cutting edge is on center or slightly above. When turning tools are reground, grinding with less clearance (10 to 20 degrees) will help to dispose of the heat generated at the cutting edge and will tend to reduce chatter by providing additional support.

Speeds ranging from 300 to 6000 rpm, depending upon the diameter of the work, are possible. A great amount of heat will be produced when turning at these speeds. Watch the cutting tool—cut shavings; don't burn the surface. Wood-turning quality steel may be used, but it will not hold an edge very long. Stellite, tantalum carbide, high-speed steel, or hard bronze should be selected if new tools are secured. Chisels made from flat files will hold their edges longer than tool-steel chisels.

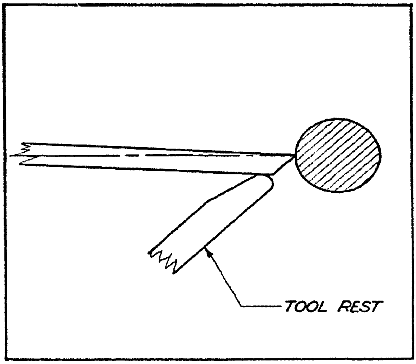
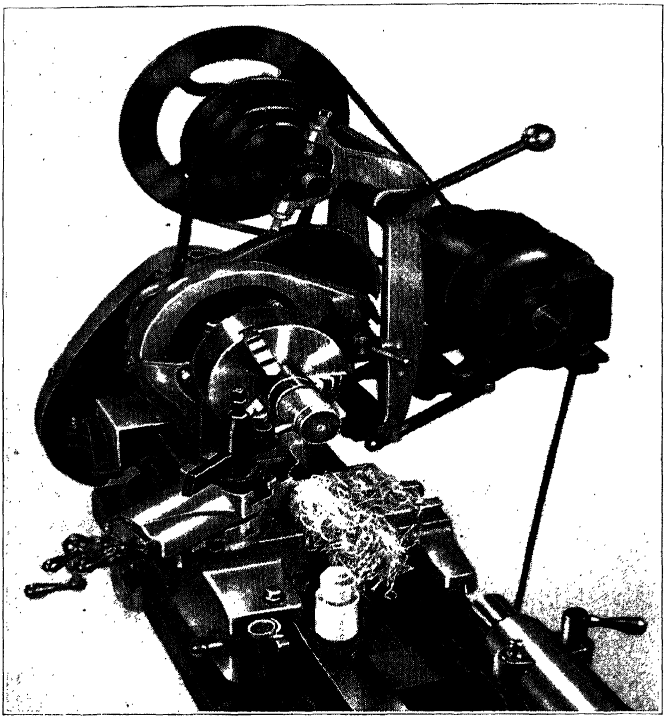


Figure 95. Correct position for a wood-turning tool.

Machine Lathe.—The problem of mounting a rod for spindle turning is essentially the same as that for mounting a steel rod. It may be mounted between centers and held by a lathe dog or it may be gripped by a 3-jaw chuck. The latter method is simpler and it eliminates the necessity for replacing the chuck.

A universal chuck eliminates the necessity of using a face plate in most cases. If one is necessary, it may be designed and turned in a manner similar to that described for arbors in Chapter 3. The diameter of the face plate should, of course, be larger. Cylinders up to 5″ in diameter can be gripped in the chuck of a small workshop lathe. If a long cylinder is being turned, a wooden cone should be turned



(*Courtesy of the Atlas Press Co.*)

Figure 96. Turning plastics on Atlas lathe.

to support the tail-stock end. Work may be mounted on arbors as previously indicated.

As with woodworking tools, machine bits should have a slight negative to zero rake. A properly shaped cutter for use on cast plastics is compared with a properly shaped cutter for use on bessemer steel in Figure 97. The tool bits are placed at the angle at which they are held by a tool holder. The kinds of alloy suitable for hand turning are also suitable for machine bits.

A machine lathe can be operated at speeds up to 2000 rpm safely. Heavy cuts may be taken when necessary—the fast feeds on the lathe are used. Lighter cuts will produce less heat and will result in a smoother cut surface. Cutters should be honed frequently.

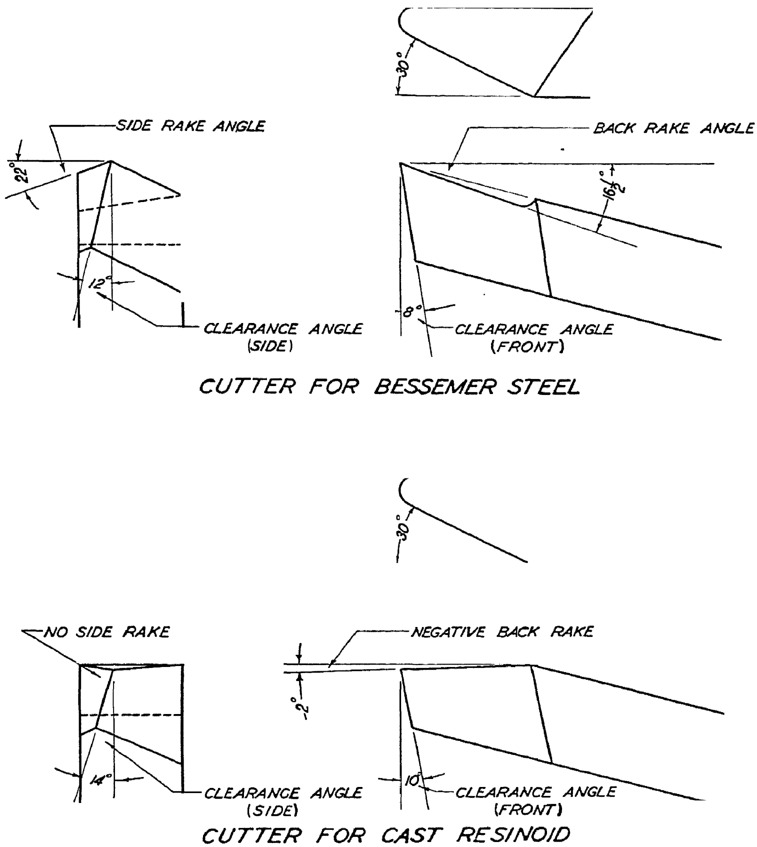


Figure 97. Correct lathe-tool bit design.

After all tool operations are completed on either type of lathe, smoothing and polishing operations should be completed before the work is removed from the lathe. For most conditions, one grade of wet finishing paper (5-0) is all that is necessary. Water may be used with the finishing paper. This operation should be followed by FF pumice stone and water and rotten stone and water. In many cases this process provides the necessary gloss.

Table I

Comparison Table of Tool Bits for Various Materials

MATERIAL	SIDE CLEARANCE	FRONT CLEARANCE	BACK RAKE	SIDE RAKE	CUTTING SPEED FT. PER MIN.	LUBRICANT
Cold Rolled Mild Steel	12°	8°	16½°	18°	80 to 100	Dry or Lard Oil
Cast Iron	10°	8°	5°	12°	50	Dry
Copper	14°	12°	16½°	20°	120	Dry or Lard Oil
Brass	10°	8°	0°	0°	200 to 300	Dry or Paraffin Oil
Aluminum	12°	8°	35°	15°	200 to 500	Dry or Commercial Compound
Molded Plastics	12°	8°	0°	0°	100 to 120	Dry
Cast Plastics	14°	10°	0° to −5°	0°	150 to 200	Turn Dry Thread with Cutting Oil
Formica Gear Material and Micarta	15°	10°	16½°	10°	200	Dry
Fiber	15°	12°	0°	0°	80	Dry
Hard Rubber	20°	15°	0° to −5°	0°	150	Dry or Coolant

Adapted from the Data Chart, Sheet No. 91, Drawer No. 19, of the Atlas Press Co., Kalamazoo, Mich.

BENDING

Synthetic plastics possess a unique property which permits them to be bent to a variety of shapes. Unlike metals, there is no noticeable change in cross-sectional dimensions. Plastics are not ductile like metals. Upsetting is impossible for all practical purposes.

Heating.—Plastics are elastic both before and after bending. The application of heat (approximately 200 degrees Fahrenheit) makes the material very flexible. Plexiglas demands a dry heat, but most other materials are heated in a liquid—either water or a water and glycerine solution. Glycerine is added to prevent the evaporation of

water and to decrease moisture absorption in certain kinds of resinoids. Cast phenolics do not absorb water; therefore clear water may be used for applying the necessary heat.

Parts should not be left in the water bath too long. A safe time limit to follow is three minutes for each one-eighth inch of thickness of material. A greater length of time may cause additional polymerization of the material to take place, which is undesirable. If a flat piece is left to lay flat on the bottom of a pan while heating, a scale may form, causing additional work in finishing. If an error is made in bending or if the plastic cools too quickly, parts can be reheated. This procedure should not be repeated too many times or the plastics will become brittle.

Clamping.—Since the plastic solid must cool to ordinary temperature before it will set or become fixed, the use of a bending form is the most reliable procedure. Examples of such forms are illustrated in Chapter 3. If a piece must be removed from the water bath and clamped in a form, all clamps should be prepared in order that the bend may be made before much cooling has occurred. Do not try to make arcs of small radius or right-angle bends. Make sure that the greatest degree of flexibility has been reached before trying to make a bend. If possible it is best to do the bending and clamping under water.

Cooling.—Provide plenty of time for the plastics to cool before it is removed from a form or clamps. Don't hasten the cooling of the clamps or forms by pouring cold water or by blowing air on them. Rapid change of temperature may cause the materials to break apart.

All bending forms should be made with smooth surfaces. If wood is used, it should be hard and close-grained. Open-grained woods tend to leave the print of the grain on the plastic surface. This blemish can be avoided to some extent by waxing the form before it is used and by applying as little pressure as possible. If a rough form must be used, a piece of cardboard placed between the form and the object will overcome this difficulty.

SURFACE ENRICHMENT

Inlaying and Overlaying.—A possibility of inlaying and overlaying opens up new fields of design for a craftsman who has become

interested in work with plastics materials. He reaches the point, after a while, where he wants to try out new combinations of color and of materials. A few materials which may be used for inlaying and overlaying include plastics sheets, metals, resinoid cement, stick shellac, sealing wax, and wood.

Inlays of plastics provide an opportunity to add a variation in color and design. Designs are cut through thin stock with a fret saw, and the edges are carefully filled. The design is then traced with a scriber on a piece of stock of the same thickness as the body stock. If the stock is thick, a router is used to cut out the waste material inside the design. Inlays are prepared in a conventional manner. Since a line of cement will show if there is any excess of open space left, accuracy is essential. Strip inlays are possible without the use of cement. A thin groove is cut in a thick piece of casting with a machine router or hand carving tool. A strip of inlay slightly wider than the groove is prepared. When the body stock is heated, it will expand enough to permit the inlay to be forced in place. Cooling shrinks the material again. Similar possibilities in design are provided by overlays if a raised portion is not objectionable. "Celluloid" and "Lumarith" lend themselves to this type of decoration.

Unlike foreign material, metals and wood may be substituted for plastics inlays and overlays. They may be cemented in place or may be held by a shrink fit. Combinations of wood and plastics look well together as is evidenced by their attractive use in furniture manufacture. Rare woods as overlays on buckles, buttons, rings, and the like, may be cemented to a plastics body.

Liquid Inlays.—Inlays which are poured or run into a recess include metals, resinoid cements, stick shellac, and sealing wax. Metals with low fusible temperatures have been used to some extent recently. These alloys melt at temperatures below the boiling point of water. They can be melted and poured in a recess prepared for that purpose. The routed design is undercut so that the metal will not drop out after cooling. By more recent methods of inlaying, metal inlays are pressed into the cellulose nitrate sheets after polymerization has taken place.

Geometric designs are carved or cut with drills as well as with a router. If a cut-out is to be filled with a liquid inlay, a greased paper should be placed underneath until the liquid has solidified. Be sure to break with a pin any bubbles which may appear as the inlay is cooling. Dyes are available for breaking the monotony of white resinoid cement and are mixed in when the cement is prepared. Other liquid inlays may be secured in a variety of colors.

Lamination.—Efficient resinoid cements make possible attractive decorative effects from built-up layers or laminations. Checker boards, trays, jewel boxes, lamp bases, and similar problems are suitable for laminating. Care in the choice of colors has a decided effect upon the finished product. Place the colors of material together to determine their eye value before starting on a problem.

Laminated sheets of plastics are also available (Appendix B) with actual wood veneers in matched, straight, or diagonally woven patterns. "Parkwood Textolite," .0625 inch in thickness, can be used for flat surface enrichment, and .035 inch flexible back for curved surfaces. Many other decorative patterns are on the market. These laminated sheets may be joined to other surfaces with most any good plastics adhesive.

PLASTIC ENRICHMENT

Perhaps the simplest method of decorating a plastic surface is that of scratching or veining an outline and "wiping in" quick-drying lacquers. Deeper impressions such as the dots in dominoes and dice may be decorated in a like manner. All surfaces are finished before the holes are drilled or countersunk. Lacquer will not stick to a buffed, glossy surface. Color is limited only by the available lacquer colors.

Wood surfaces are often decorated with an electric burning tool. The same tool is effective for producing outlines on a plastics surface. The point is hot enough to char a small portion of the material and leaves it a brown color along the outline.

Carving.—Hand carving is done in much the same manner as on hardwood, ivory, or bone. It is accomplished by hand tools, machine carving burrs, or small abrasive wheels. Practically anything that can

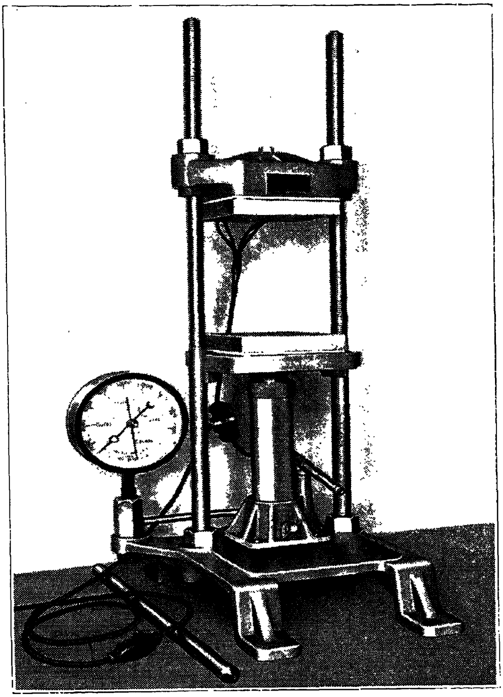
be used to cut hard wood or bone can be used to carve cast resinoids in some way. A knife may be used with a scraping section; an old file can be ground to make a blunt-edged carving tool; a set of wood-carving tools may be used to a minor degree; and even a wood chisel may be used for certain types of cuts. Hand tools are more effective if the work is heated frequently in water to about 150 degrees Fahrenheit. Hand-carved work may be left with a frosted appearance as the tools leave it, or it may be polished like flat surfaces. Carvings with deep impressions will be found difficult to polish.

Figure 98. "Super Crafty" rotary tool used in shaping belt slide.

A variety of machines are suitable for carving. An expensive carving spindle is not necessary. Carving burrs may be held in a drill-press chuck or lathe chuck and operated at from 4000 to 5500 rpm. These burrs, in the same manner as dentists' drills, may be held in a small flexible shaft and operated from a jack shaft or other power source at similar speeds.

Various high-speed hand carvers and grinders (Appendix B) are on the market and are practical in their own fields. Figure 98 shows a belt buckle being carved with a "Super Crafty" rotary tool. The speed of rotary tools varies from 10,000 to 18,000 rpm. A variety of operations may be performed by these tools because of the large number of attachments.

Engraving.—Rings and costume jewelry furnish an outlet for the engraver's art. Metal engravings are suitable for plastics. True synthetic gems may be shaped by faceting. Unless a commercial gem-cutting machine is available, only a small number of facets should be attempted. An ingenious craftsman with sufficient patience and interest along these lines will find artistic inspiration and an excellent opportunity to display his ability in synthetic resinoids.



(Courtesy of Fred C. Carver)

Figure 99. Carver laboratory press.

Grinding.—Coarse grinding wheels provide an easy method of cutting to dimensional curves—the type of irregular curve which may be found on statuary. Small grinding wheels may be used on rotary tools for rough carving instead of the regular cutting burrs. For roughing cuts a file would cut much more slowly than a power grinder.

Coarse grinding wheels are recommended because they cut faster and do not clog with the cuttings.

Embossing.—One who has worked with cast phenolics for a while and has watched them react to a bath of hot water will wonder about the possibilities of embossing. This is one of the industrial processes performed in the manufacture of buttons which can be done on light equipment in a small laboratory.

Dies to be used for pressing may be made from hardwood blocks or brass. Designs to be pressed should be shallow but have sharp outlines. Buttons and other costume ornaments furnish starting points for a craftsman's ingenuity.

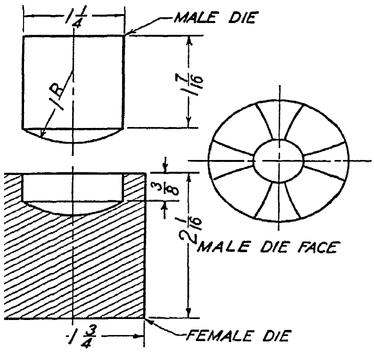
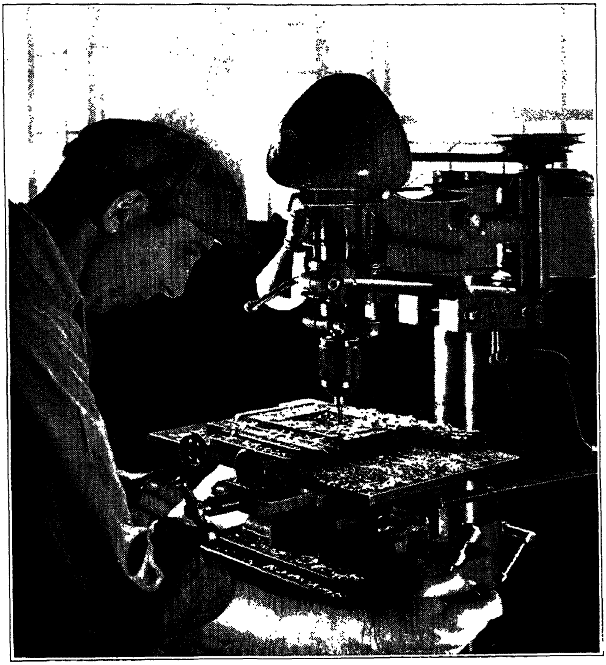


Figure 100. Embossing dies.

Material thicker than 1/8″ should not be attempted. Three thirty-seconds should prove more satisfactory for average use. Blanks are heated in water (180 to 200 degrees Fahrenheit) for a few minutes. They are placed in an unheated press and pressure applied. Pressure is held for some ten seconds until the disc has lost most of its extra heat. A drill press, a bottle capper, a machinist's vise, and a small laboratory press are suggested as devices for providing necessary pressure.

Routing and Shaping.—Machine routing may be done on a drill press, on a small portable high-speed router, or on a router attachment placed on a drill press or jig saw. The latter two methods are desirable but require rather expensive equipment. Unless production

work is attempted, a drill press with a rigid spindle, accurate chuck, and good bearings will operate adequately. All routing operations shown in this book in connection with project work were performed on a drill press operating at 4000 rpm. Router bits or carving burrs may be used.



(Courtesy of the Delta Mfg. Co.)

Figure 101. Routing base of a plastics ink-well stand.

A drill press may serve an additional purpose—that of a shaper. A few cutters will make it possible for attractive edges to be added to flat work. Any shaping set-up should have small cutters, because the thickness of stock used will usually be $\frac{1}{2}''$ or under. Surface areas and arcs of curves will be small also.

For efficient work in both shaping and routing, high speeds up to 10,000 rpm should be used. If slow speeds are necessary, several small cuts rather than one heavy cut should be taken.

Swaging.—Thermoplastic materials, such as cellulose acetate and cellulose nitrate, readily lend themselves to the process of swaging. Shallow trays, plates, and dishes may be made by heating thin sheets to the plastic stage and pressing between properly shaped dies. Since cold dies are used, they should be pressed together quickly before too much heat is drawn from the plastics. As soon as the plastics has cooled, the dies may be removed. Swaging cast resinoids would also be possible if the material could be secured in the "B" stage, or partly cured form.

Chapter 6

Surfacing, Finishing, and Assembling Operations

THE PRECEDING CHAPTER has included operations involving forming and cutting to size and shape. Problems at this stage, however, are not complete. An even surface must be prepared, beauty of material has to be brought out, surface gloss must be provided, some method of holding parts together must be selected, and a fastening device is to be applied.

Usually a new problem presents itself at this time, that is, whether certain parts can be finished best before or after assembling. A careful analysis of the finishing equipment to be used and the assembly operations will usually solve this problem. A laminated gearshift knob, for example, can be surfaced and polished much more easily after all parts are cemented, while most lamp bases can be surfaced and finished more easily before assembling.

SURFACING

All sawed areas must be surfaced. It is necessary to prepare each surface of a cast resinoid by preliminary operations before it can be polished, even though it has been touched with a saw. A casting comes from the lead form with a dull surface which does not show the natural beauty of the material. Oftentimes the application of fine abrasive papers or the ashing process is all that is necessary; at other times, there are scratches produced by handling, or pits from the mold which require other treatment. A workman should inspect the piece which he is using for warp and wind before attempting to prepare a surface. If it is uneven, it may be made level by heating it for a few minutes in water just below the boiling point, placing it between two pieces of glass, and allowing it to cool in this position.

Hand Surfacing.—If a surface is too rough to be sanded it can be planed. Sharp plane irons are essential. Because of the angle at which

the plane iron is held in the plane and because of the support close to the cutting edge, a block plane is better adapted to planing cast plastics surfaces than any of the other planes. A smoothing plane or jack plane may be used for preliminary work in straightening an edge, but neither should be used for final surfacing. These planes remove the cuttings in short broken shavings instead of in long paper-thin shavings as does a block plane. Holding the piece to be planed in hot water for a few minutes before planing will make this operation much easier.

Only the finest of abrasive papers are necessary, after finishing with a block plane, to remove the minute scratches produced by the cutting edge. Flat surfaces may be planed as well as thin edges and ends if the plane is held firmly against the work.

All irregular shapes have areas which cannot be planed; these must be treated differently. Files are used in a preliminary surfacing operation under these conditions. Uneven places may first be removed by cross filing with a file that best fits the area. Rough cuts which are necessary when some waste stock is to be removed should be made with a second-cut file and followed by a fine file. Small flat areas may be surfaced by draw-filing. Small irregular curves as well as square corners in crowded places may require a set of needle files before they can be smoothed.

Machine Surfacing.—A *jointer* set for a very fine cut may be used for smoothing laminated stock built up of cast resinoids and held together with plastics cement. Pieces shorter than 8 to 10 inches should not be attempted. Pieces this length and longer may be jointed on machines where the tables can be brought close enough together to insure a margin of safety. Heating in water as in *Hand Surfacing* will take away most of the brittleness and help produce a smooth surface.

After forming and shaping operations have been completed, a *disc sander* with fine abrasive may be used effectively for surfacing. If a disc sander is not available, a *belt sander* may be used instead. With a little practice, the use of either sander will save a great deal of time in the leveling of areas with results that are easily obtained by hand. Moving the work back and forth on the abrasive disc or belt will produce a better surface and prevent "clogging" of the abrasive.

It is difficult for a beginner to file certain edges square with a face. A jig will prove its usefulness if a set of machine files are available. Work may be shaped more accurately and quickly by machine than by hand. This machine is especially helpful where no additional smoothing beyond a filing operation is necessary.

Curved and irregular surfaces that cannot be reached by the larger sanding machines require a different process. Small *sanding drums* (see Figure 68) mounted in a drill press or in a lathe may be found useful.

FINISHING

Up to this time, all operations have been designed to prepare a surface suitable for finishing and polishing. The purpose of this group of operations is to secure a smooth, even, glossy surface which possesses a high lustre. All of the work may be done by hand, or it may be done, for the most part, on buffing wheels. Cast resinoids possess remarkable beauty and it remains for the workman to bring out this beauty. If he is successful, he will experience a thrill equal to that of handling the finest of jewels.

Hand Finishing.—Except under rare conditions, the first smoothing operation after surfacing is that of hand sanding. The condition of the surface area determines the grade of abrasive paper to use. Wet-or-dry finishing papers prove most economical, even though the initial cost is more than that of sandpaper. Finer abrasives are necessary for finishing plastic surfaces than are necessary for finishing wood or metal surfaces. Only in rare cases will a paper coarser than 1-0 be necessary. Grades running down to 7-0 or 8-0 can be used to advantage before abrasive powders and compounds are applied.

Fine abrasive papers clog with powder quickly if used dry. Water helps to keep the paper clean and makes the abrasive cut faster. There is no grain in these synthetic solids, therefore, sanding can be done in any direction. It is a good practice to rub with each grade of paper at right angles to the direction used with the preceding grade. In this manner the scratches from a previous sanding can be removed. It may be impossible to see these if all sanding is done in the same direction. Coarse scratches, for this reason, may not be detected until the surface is buffed.

Powdered pumice and water are used after the finest abrasive paper. A generous portion of powder on a pad will cut rather rapidly. It is possible to smooth irregular areas better with a flexible pad than with paper on a rigid pad. Pumice leaves the surfaces with a smooth, dull appearance. Rotten stone and water or rotten stone and oil are used for the final hand-finishing operation. Surfaces should be cleaned of all powder and lubricant. The finished surface should have an attractive gloss, but it does not have the high lustre made possible by a coloring operation on a buffing wheel.

Machine Finishing.—The old adage, "Many hands make light work" is certainly true of finishing plastic surfaces. The tiny particles of abrasive are the tools, and the power used on a rapidly revolving buffing wheel represents the hands which make the finishing task light. One should not become over-ambitious and put too much pressure on the work when he finds that a buffing wheel will do the job. Friction between an abrasive compound on a buffing wheel and the work produces heat in abundance. Only a short time is required to reach the safe temperature limit. Too much heat generated with no way of escape will cause the plactics surface to break down.

An analysis of finishing operations as they are performed in industry may prove of value. These operations are grouped (22-262-266) in Table II. The abrasives used are included for each operation.

Sanding.—Sanding may be performed by hand or on a machine sander with abrasive papers, or by placing it in a tumbling barrel with a "harsh" abrasive mixture. In a small laboratory, the last method is impracticable, since the necessary pieces of equipment are seldom found there. This operation may be done by hand following the method outlined under *Hand Finishing.*

Ashing.—Ashing operations include the abrading of a surface by an abrasive (usually wet pumice powder) applied to a buffing wheel and cutting in a tumbling barrel with a similar abrasive. The tumbling process here falls in the same category as it does under sanding operations. Ashing on a loose buffing wheel, with wet pumice is very effective but requires the addition of a pan under the wheel and a guard behind and over the wheel—they are usually in the same piece.

Modern finishing compounds have made this wet process unnecessary. The "Lea Method" of finishing (41) provides a dry method with a loose muslin or canvas wheel. Lea compound, grade "C," which is an all-around grade, is recommended for Bakelite and Catalin (41-16). It contains silicon carbide and aluminum oxide in a greaseless binder. A more recent addition to the Lea line, grade "S," is also recommended.

Table II

Operations and Abrasives Used in Finishing Plastics

NATURE OF OPERATION	MESH SIZE OF PARTICLE	RELATIVE SIZE OF PARTICLE	TYPICAL ABRASIVES
Roughing			
A. Sanding	50-100	Coarse	Coarse pumice, emery, garnet, aluminum oxide.
B. Ashing	80-150	Medium	Medium pumice, silica, Lea Compound, Grades "C" and "S".
Polishing			
A. Buffing	150-450	Fine	Tripoli, rouge, aluminum oxide, chalk, Learok Grades S-28, 119 and 436.
B. Coloring	450 and up	Very fine	Lime, rotten stone, Nu-White, Learok Grades Nos. 304-B, 746 (Buffing and coloring), and 756 (coloring).

Buffing.—Buffing operations are performed on a loose muslin wheel. Grease-bound compounds such as Tripoli are used successfully, but they leave a surface with a greasy appearance which shows finger prints. The object must be cleaned after buffing when a grease-bound abrasive is used.

Learok, Grades S-28 and 436, are greaseless compounds which are recommended for this operation. If only one buffing wheel is available, a small amount of Learok S-28 may be applied to the cutting or ashing wheel after that operation has been completed. The buffing operations may be continued on the same wheel.

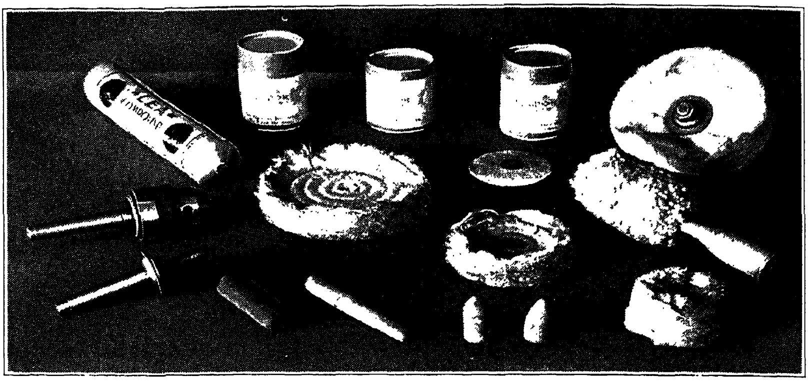


Figure 102. Buffing compounds and equipment.

A speed of 2200 to 2500 rpm proves very satisfactory for 6″ buffs. Buffing well done is often the last operation.

Tumbling.—Tumbling is a typical factory process for finishing quantities of small articles at a minimum cost. Only a general method of tumbling can be dealt with here since each manufacturer varies the procedure to suit his own particular needs.

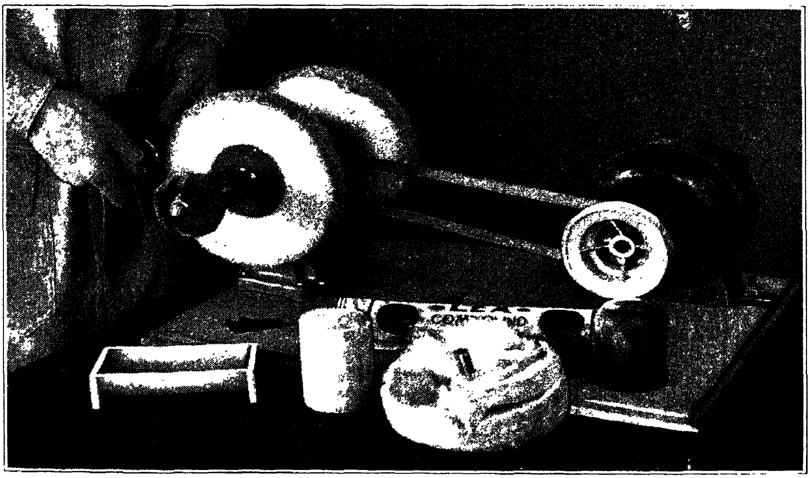
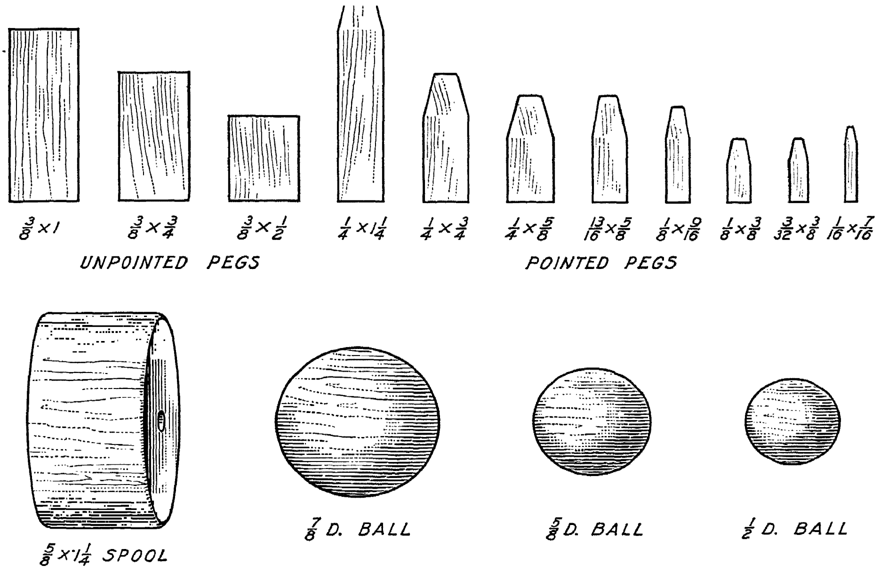


Figure 103. Buffing operation.

In the same shop, the process will vary according to the material used, the surface condition, the size of the article, and the finish required.

Most articles finished by the tumbling process come direct from cutting wheels, dies, or molding presses. The roughing process is used to remove the die flashes and scratches made by cutting wheels. Quartz sands, ground glass, emery, carborundum, pumice, and ashes are some



(Courtesy of Lupomatic Tumbling Machine Co., Inc.)

Figure 104. Tumbling equipment—pegs, balls and spools.

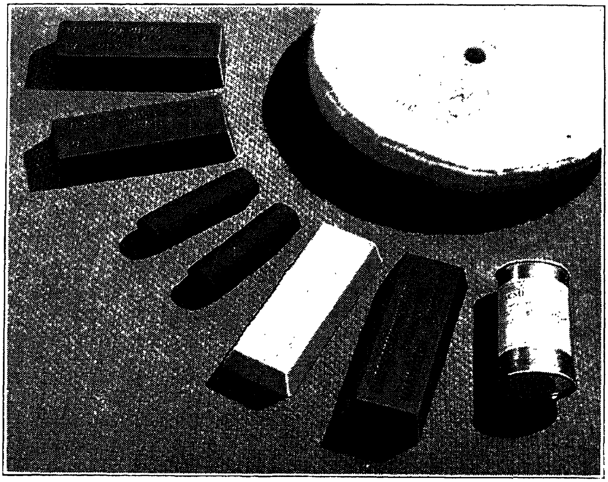
of the abrasives used in tumbling barrels. Wooden pegs and balls are often added as carrier agents for abrasives.

Articles coming from the tumbling barrel must be thoroughly cleaned before entering the finishing barrel. Sawdust and water are often used as the cleaning agents in the second barrel. This operation usually requires only a short time.

The final tumbling process is that of *finishing*. Here tripoli, chalk, polishing oils and other recommended compounds, such as Lupomatic's Quicklustre Cream, are used. When cream compounds

are used, the pegs are coated first, then the articles are added. This process may require from 12 to 36 hours. In general, tumbling barrels are operated at 20-40 rpm, depending upon the type of article and the material from which it is made.

Coloring.—Coloring indicates a high-lustre finish. A loose muslin or flannel wheel is used. Compounds that have proved satisfactory for this operation are: Nu-White compound, Learok Grade 304-B, Learok Grade 746, and Learok Grade 766.



(Courtesy of Hanson-Van Winkle-Munning Co.)

Figure 105. Loose full disc cloth buff and buffing compounds.

Heat and friction, along with a little very fine abrasive, bring out the inherent beauty of cast resinoids in this operation. A clean, soft wheel at this point will provide a finishing touch by leaving it free from finger prints and wax.

A variety of speeds for buffing wheels used in finishing operations has been recommended by manufacturers. Such recommendations usually cover large equipment found only in industry. Six-inch or eight-inch wheels are used in the small workshop. Maximum speeds of 5000 rpm for six-inch wheels and 3750 rpm for eight-inch wheels are recommended (22-264) for cast phenolics. Cellulose derivatives require slower

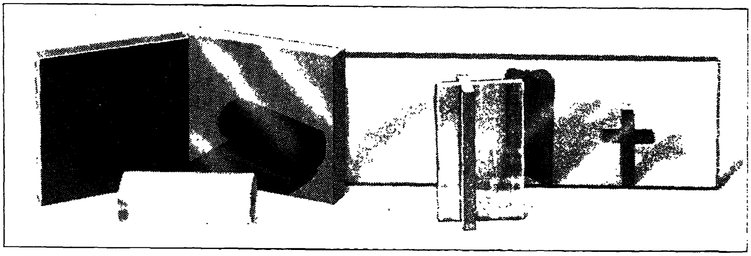


Figure 106. Finished and unfinished surfaces.

speeds. Speeds ranging from 1750 to 2400 should prove more satisfactory for general work on wheels of the diameters just given.

The procedure suggested for polishing and buffing plastics may be used successfully on the softer metals. There are many conditions which require the polishing of metal for decoration of plastic problems. A separate buffing wheel should be provided for metals, because they will darken a wheel so that it will have to be cleaned before being used again on synthetic surfaces.

JOINING

There are many small problems which can be made from synthetic plastics by shaping one piece of material. Before a craftsman proceeds far, however, he will wish to make something composed of two or more parts. There are many methods of holding such parts together, but cementing is the least involved and perhaps has the widest application. If a cement job is properly done, the joint will be as strong as the material itself. Modern design in the use of thin-sheet plastics has created

Figure 107. Plastics cements.

a demand for transparent, waterproof cements. New materials and new cements are coming into use almost daily.

Cement.—Each manufacturer of resinoids recommends a special cement, prepared at the factory, for cementing his own materials together. Since plastics are non-porous, glues such as hide glue, fish glue, amberoid and the like, cannot be used as permanent joining agents.

Most manufacturers of cast resinoids now produce a transparent cement in addition to the original opaque cement. Joints made with transparent cement are much less noticeable than those made with opaque cement. An explanation of the method of preparing special resinoid cements may help to understand their usefulness where others fail.

Cast-resinoid cements, or cements for thermosetting materials, consist essentially of the raw resinoid itself. It has not been permitted to cure, or polymerize. If in this state it is spilled on anything, it will remain as it is for a long period of time. In order to bring about polymerization, conditions similar to those in preparing the solid plastics must be provided. The application of dry heat at 200 degrees Fahrenheit for some twelve hours would cause the cement to harden. Hydrochloric acid is more commonly used to accomplish this purpose. A 75-per cent solution of the acid is added to the uncured resinoid syrup, it combines with the small amounts of moisture therein, and heat is generated. This reaction provides the necessary heat for polymerization.

Cement and acid should be mixed on a glass plate with a glass stirring-rod. The time required for the cement to set is determined by the amount of acid used for a given quantity of cement. Proper proportions are one part acid to 12 parts resinoid for at least one cast phenolic product. These proportions are difficult to obtain, however. If a glass stirring-rod is dipped in the cement, then, with the cement clinging to it, the rod is removed and dipped in acid, a proper amount of acid should cling to the rod and cement. Larger quantities may be mixed by using a medicine dropper or a small glass tube as a pipette to transfer the acid to the resinoid. In this way the amount of acid may be measured rather accurately.

If too much acid has been used, the cement hardens before it can be applied to surfaces that are to be joined and the clamps set. If too little acid is used, polymerization does not take place. Experimentation is the best guide to follow. Select one method and set of equipment and stick to them after satisfactory results are secured.

The most noticeable effect of the acid on the cement is that of turning it from a clear resinoid to a white fluid. Make sure that enough stirring has been done to produce an even color and texture before applying it to a plastics surface. A 10-per cent solution of ethyl alcohol is used as a thinner and as a solvent for removing excess cement around a joint before it sets. If alcohol is used, it must evaporate from the joint before the cement sets.

The same procedure may be followed in using transparent cements except that the formulas for mixing may vary. In order to simplify this process accelerators may be purchased along with the cement (Appendix B). Printed instructions are attached so that even an amateur should be successful. For using Garrett's Transparent Cement the following directions are given: "To four parts of Transparent Cement, add one part of accelerator." In all cases where cements are used, the parts must be held firmly in a clamp or vise until the joining agent has "set." This procedure requires from 4 to 12 hours, depending on the nature of the joint, the amount of accelerator used, and the room temperature. Excess cement around joints may be removed with the same solvent and procedure as used for opaque cement.

Acetate plastics offers to the beginner, as well as to the experienced worker, the advantage of using a solvent for a cement. A bond thus formed is usually much stronger, and less noticeable, than if made with cements other than solvents. Acetone is used to cement acetates. A surface is prepared in the usual manner and the joint sealed with acetone. A period of twenty minutes to one hour is usually required for setting. Since acetates soften in alcohol, it is better to use filing and sanding operations for removing surplus cement. Buffing and coloring operations are the same as for thermosetting plastics, except that the work must be dipped in cold water often to keep down the accumulation of heat.

Cascamite Plastic Adhesive in the form of dry powder synthetic resin can also be purchased (Appendix B). This cement is mixed with cold water and when dry is highly resistant to moisture. Williamson's Liquid Adhesives of a thermoplastic nature are also available and recommended for use with cast resinoids as well as laminated plastic material.

The quantity of cement purchased at one time should be proportionate to the need. The filled container should be stored in a cool place and kept tightly sealed. The cements using acid accelerators cannot be kept safely for periods longer than three months. Dry powder forms and liquid adhesives may be kept for longer periods.

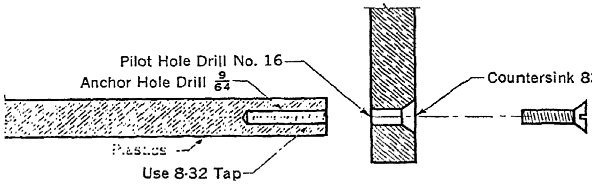


Figure 108. Machine-screw assembly.

A cemented joint should be made on sanded surfaces before any buffing is done. Before it has completely hardened, excess cement at a joint may be trimmed off quite easily with a linoleum block knife. After hardening, cement may be machined in the same manner as the plastics itself.

There is a tendency for all cemented parts to *creep* before the cement has set, even after clamps have been applied. Producing an accurate joint, where the finished parts must fit in a definite relationship to each other, is a difficult task if there is not some means of preventing the parts from slipping out of position. Small metal dowels, accurately placed, will solve the problem and give additional strength to the joint.

Machine Screws.—The application of machine screws is practicable wherever the thickness of the stock is great enough to permit it or where it may be necessary to disassemble a problem. Standard machine-screw taps and dies are used. No lubricant is necessary. Care should be taken to start a tap in exact line with the pilot hole. A table of tap and drill sizes may be found in Appendix B. An average tap should be cleaned at least twice when cutting threads the full length of the

threaded portion of the tap, because cuttings quickly fill up the flutes in the tap. For this reason, screw threads finer than 32 per inch are difficult to cut.

The most common assembling sizes requiring tap-cut threads are 6-32 machine screw, 8-32 machine screw, and $\frac{1}{8}''$ pipe nipples. Where parts must be separated frequently, as is the case with a safety razor handle, a small brass insert is advisable.

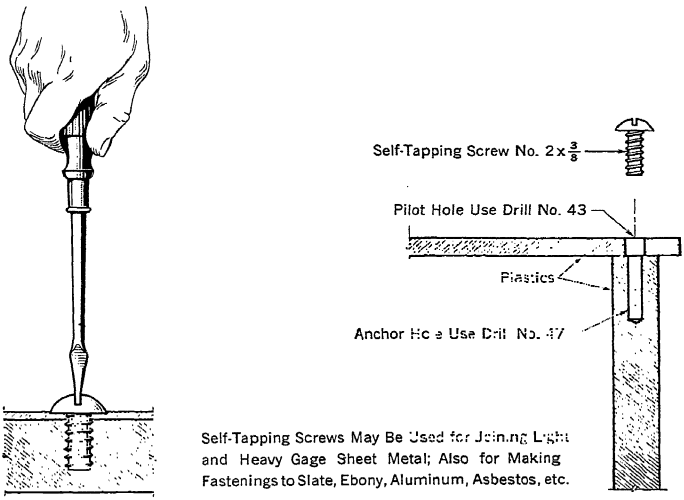
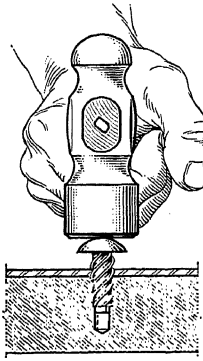


Figure 109. Self-tapping screw assembly.

Self-Tapping Screws.—These hardened screws may be applied with less expense than that involved with machine screws. No taps are necessary. A hole of the proper size is drilled and the screw is driven with a screw-driver (Table V. Appendix B).

Because of the nature of the thread, this type of assembly is claimed (37-138) to possess greater strength than a machine-screw assembly. A joint thus made may be disassembled a few times if occasion demands.

Drive Screws.—These holding devices are much used for securing findings to costume jewelery (see Figure 110). If the recommended drill size is used, it is almost impossible to remove pins and other findings held with this device without breaking the plastics. A drill is the only special equipment necessary. Head shapes, other than round,



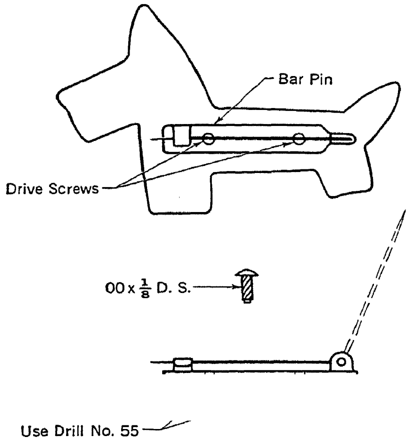


Figure 110. Fastening metal to plastics with drive screws.

are special and are difficult to secure. Finishes such as nickel-plated, cadmium-plated, electro-galvanized, and grass plated are available as standard merchandise.

Rivets.—There are occasions where infrequency of use does not warrant the purchase of special holding devices, especially if they are not stocked by a local hardware store. Rivets of soft metal may be used to advantage in such cases. Escutcheon pins are quite common and appropriate. The rivet hole should be countersunk slightly on the back surface to provide for swelled metal. Soft metal rivets of aluminum or copper must be secured to avoid the danger of breaking the material when the end is riveted.

Figure 111 illustrates a common use of rivets. Broken knife handles are easily replaced by fitting stock of the proper thickness, to the sides and then riveting. Occasionally dipping the handle in hot water, while the riveting process is going on, will tend to keep the thin plastics from breaking.

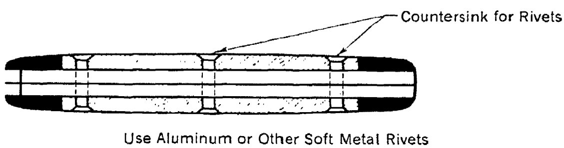


Figure 111. Knife handle assembled with rivets.

DRILLING AND TAPPING

The problem of drilling synthetic plastics may be described as similar to that of drilling brass. Brass requires drills of different design from those used on steel and similar metals. Common twist drills are not suitable in the larger sizes (over $\frac{3}{8}''$) because they tend to "hog in" and spoil the piece for further use. Special drills, called straight shank, straight-fluted drills, have been manufactured for brass and are best for plastics.

Twist drills may be adapted for use on these synthetic materials by grinding the lips so that they form an angle of about 90 degrees with the surface being cut. This is termed a "negative rake." Small sizes

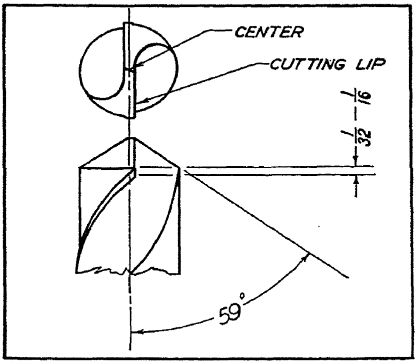


Figure 112. Twist-drill bit properly ground for drilling cast resinoids.

of ordinary metal drills, reamers, and countersinks may be used with safety at high speeds. Larger sizes may be used only if extreme care is taken. Always keep in mind the danger of a drill's "digging-in" and guard against it.

Small holes are drilled with carbon twist drills at high speeds, but the cuttings should be cleaned out frequently; otherwise the cuttings may pack in the hole and prevent the escape of the gases formed. A small explosion may result and break the work apart. When drilling through a slab of material with ordinary drills, the drill should be fed from the opposite side as soon as the point starts through. Chipping is thus prevented.

As to hand equipment, any metal drill or reamer may be used, with care. There are few situations where a hand drill cannot be used for the same work as a power drill. Power drills usually provide greater speed and accuracy. Wood-boring bits may be used on occasion as substitutes for metal bits when greater length is needed.

Tapping.—One of the machines, lathe, power drill press, or hand drill press, may be used for tapping to insure greater accuracy. Power may be used on a lathe operating at slow speeds. If this is not possible, the machine is turned by hand.

Chapter 7

Design for Plastics

CIVILIZATION is taking on a renewed interest in the appearance of all things with which people come in contact. Art and design are finding a place outside of museums. Artistic expression may be found in the most humble dwelling because manufacturers have realized a universal need for industrial design.

Years ago, a well-known American architect, Louis Sullivan, stated a fundamental principle of design. His statement, "Form follows function," ushered in a new development in the field of architecture. This hypothesis leaves no place for the imitation of Grecian temples or the Roman Pantheon in office-building architecture, and does not permit bear claws on divan feet or lyre backs on dining-room chairs. Cathedrals are built to look like cathedrals, office buildings are designed to lend dignity to their use, and homes are planned to look like places where people *live* rather than *room and board*.

Walter Dorwin Teague has expressed the aim of modern contemporary industrial designers (78-53): "The function of a thing is its reason for existence, its justification and its end, by which all its possible variations may be tested or rejected." Much of the gingerbread so common a few years ago is being omitted from industrial products. There is, unfortunately, a tendency to "streamline" many objects when there is no necessity for it. Manufacturers have become so "streamline" conscious that many of them apply the term to any design which tends to soften harsh rectangular or square corners by substituting a few radii. It is only in the fields of transportation and hydraulics that true streamlining is functional.

MEANING OF DESIGN

Van Doren (82-121) states that "Design is fundamentally the art of using lines, forms, tones, colors, and textures to arouse an emotional reaction in the beholder." This statement does not permit the inclusion of crude geometric shapes merely because they serve their purpose well,

for they would not arouse a desirable "emotional reaction." Neither Sullivan nor Teague would insist that the end of all design was pure functionalism. Such a theory would reduce design to a mere formula. A design would then be a mere skeleton which would enable an object to meet its use in an acceptable manner, but it would be stripped of its human touch—that which provides the character that makes a consumer want to possess it. It was Ruskin who suggested that "Not all of the mechanical or gaseous forces of the world or all of the laws of the universe will enable you either to see a color or draw a line without that singular force anciently called the soul." Artists, therefore, give to all of their work an individual touch which makes the thing exciting to all who experience it. A dozen designers working on the same idea will produce as many types of expression. Such a variety of expression provides appeal to consumers of a wide variety of temperament. This appeal causes them to sacrifice something to procure that which they desire.

There is a place for individuality in design, as it applies to the practical arts, just as there is in the so-called fine arts. A realization of this fact has brought these divisions of art closer together. Someone has said that the greatest need of the applied arts is more *design* and that of the fine arts is more practicability. Progress in reaching these achievements is being realized. Perhaps, in a short time, the breach between applied arts and fine arts will narrow to the point where the two may unite in a common purpose so that emotionally pleasing and functionally efficient merchandise will be available in our department stores and similar architectural structures in evidence on our landscapes.

There are many guiding principles which should be observed by a designer, but it is questionable whether they should be reduced to formulas. Would such a procedure eliminate individuality in design and result in a failure to arouse individual reactions?

THE INDIVIDUALITY OF PLASTICS

Progressive education has come to a realization of the fact that individual treatment is the best approach in the educational process. Seldom do any two people think, act, or respond in the same manner because

they have not had the same background of heredity and environment; therefore individual handling is believed to be the wise practice. So it is with construction or art materials. Wood differs from plastics, steel differs from pewter, oil colors differ from water colors, and glass differs from rubber. No amount of ingenuity on the part of a designer or fabricator may make all of these materials, or any two of them, fit into the same groove. Each possesses an individuality of its own.

All parts of an object designed of wood, metal, plastics, glass, or clay should give the appearance of a unified whole. No ornament should give to the observer an appearance of being "stuck on" or of being included as an after thought. Ornamentation with different materials may be included if the materials themselves fit together in terms of color, texture, and shape, and if it serves a definite purpose in the design of the object. Varnum (83-78) states: "Each material speaks to the designer; learn its language."

Plastics possesses an inherent beauty which arises from texture, finish, and color, which does not require an abundance of ornamentation or surface decoration to make an object, fabricated from the material, stand out. Let the reader take a slab of plastics and handle it. Compare it with a piece of steel, a piece of wood, and a piece of glass (all unfinished). Handle each of these materials after they have been surfaced or sanded. Examine the texture of each material and determine just what treatment will bring out its beauty. Buff a portion of the plastics slab and compare its texture with a sanded or dull portion. Is there a place for each type of finish? A statement by Laurence Steme, "Beauty, like truth, is never so glorious as when it is plainest," might be applied at this point.

There are three factors which affect, in varying degrees, the form of an object: its function, the kind of materials, and the method of working. Examine plastics as a *material*. Is it soft like clay or hard like glass? Can it be bent into sharp corners like steel or joined together like wood? Does it lend itself to sharp corners like a solid metal design or to softened arrises and flowing effects at corners? Can the material be shaped with saw, plane, and gouge like wood or must it be drilled, chiseled, and filed like steel? Figure 113 illustrates the influence of materials upon the form of an object.

Each industrial or craft medium possesses properties which are peculiar to itself—they differ both in minor and in radical ways from other media. Ordinary glass is brittle, and breakage is a constant concern when it is being fabricated; gold is extremely malleable and may be shaped into very fine sheets; carbon steel may be soft enough to be machined quite readily, or it may be made so hard by heat treatment that it can be cut or shaped only by grinding; one type of plastics may be a soft pliable mass at one stage of its development and at another be

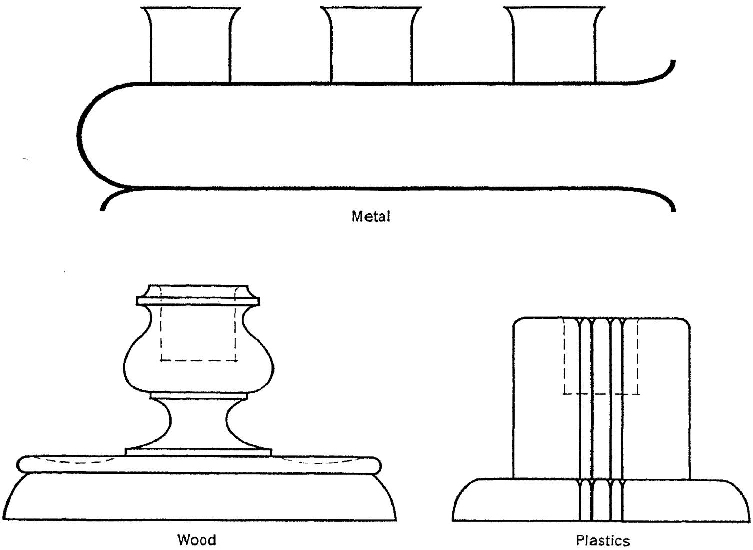


Figure 113. Candle holders showing influence of materials on design.

an insoluble, infusible solid; wood possesses a grain structure and long fibers which must be reckoned with in a still different manner because of its abrasive properties.

Steel may be rolled into thin sheets and objects can be formed from these sheets by bending and pressing. A dustpan is a typical object to which steel is adapted. Neither glass nor wood can be adapted easily to this particular object. A molded, laminated plastics might be successfully adapted to a dustpan design, but the design would, of necessity, be peculiar to plastics.

After examining plastics, as a material, and comparing it with other structural materials, one may readily reach a conclusion that straight lines should be predominant in plastics design. Both the stock sizes and shapes in which plastics may be procured and the very structural strength in relation to function indicate this type of design. Whenever curves are necessary to support a design, the designer should tend toward the more interesting elliptical curves rather than circle arcs and should avoid small, tight curves except in the case of relieving sharp arrises.

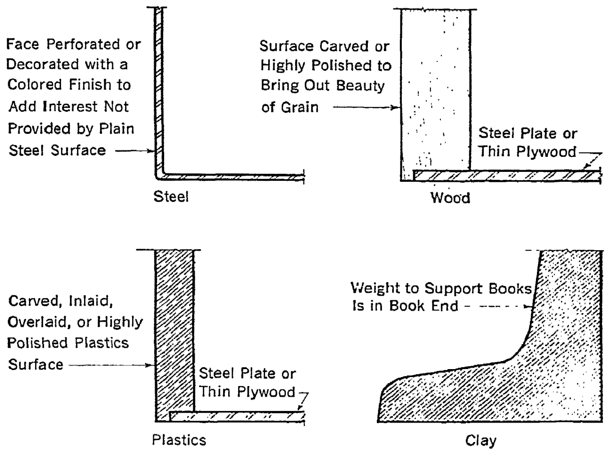


Figure 114. Details showing the influence of the mode of working upon design.

Let us consider an object, a book end, which might be constructed from any one of the following materials: wood, steel, clay, or cast resinoid. The nature of the method of working and the properties of the materials alter design as indicated in Figure 114. Steel book ends can easily be fabricated from a single sheet by bending at a right angle. The plate which fits under the books, both on the wood design and on the plastics design, is necessary to make a book end *functional,* but it need not be as attractive as the rest of the object. Sufficient weight to support books is provided by a heavy clay structure which is either cast or modeled by hand.

A fourth factor, stock sizes and shapes, influences the design of cast resinoid articles. The common standard shapes are sheets (ranging in thickness from $\frac{1}{8}''$-1″), rods (ranging in diameter from $\frac{1}{4}''$-5″ and in length from 6″-20″), and tubes or cylinders (ranging in I.D. from $\frac{1}{2}''$-7″, in O.D. from 1″-8″, and in length from 4″-16″). A design of a plastics article should not, therefore, call for a 10″ cylinder to be shaped into the side wall of a dish if the largest cylinder available is 8″ in diameter.

Design in plastics demands, for the most part, details of thin cross-section. As yet, plastics are expensive structural materials with prices ranging from 45 cents to $1.60 per pound. Attractive articles may be made at low cost only if the designer takes this fact into consideration. Economy of material is a wise point for a craftworker to consider, both from the viewpoint of dollars and cents and from that of design. It will result in simplicity of design—a feature to which plastics lends itself readily.

One who would be successful in designing plastics articles must study and understand the general principles of design. "He should also form the practice of continually analyzing examples of work to learn why they are satisfactory, or in what ways they fall short" (55-21). Where is the object to be used? What is its function? What ornamentation may be added to attract the interest of an observer? Does the ornamentation serve a purpose in the structure of the object? Is the design practical in terms of *mode of working?* Intelligent answers for these questions will be reached by the wise designer. Last of all, he will ask himself, "Does the design speak the language of plastics?"

In Chapters 8 and 9 will be found numerous designs for problems of varying difficulty to be constructed from cast, laminated, and thin-sheet plastics. All designs are to be considered as suggestions only. There is no intention on the part of the authors to initiate a stereotyped course of study in construction work nor to outline such a set of problems for the craft worker. Dimensions are intentionally omitted from many of the plates. There are few complete working drawings. On many plates, there is one design, complete in most details, and several suggested designs which require similar over-all dimensions. The beginner is given an opportunity to develop a sense of discrimination

in design. In developing all designs, the reader should remember Leonardo DaVinci's principle, "Every part is disposed to unite with the whole, that it may thereby escape from its own incompleteness."

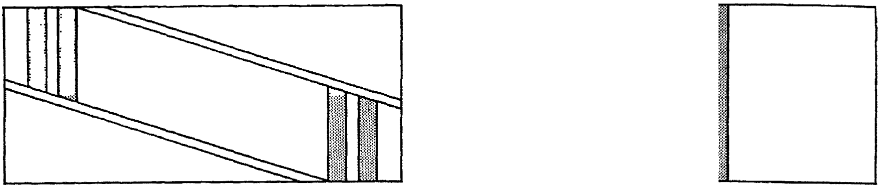
DESIGN FUNDAMENTALS

An artist-craftsman will early realize the limitations of his material and keep them constantly before him. A designer needs to keep before him several fundamentals of design or rules of procedure. The reader should keep in mind that these principles are not objective in many cases because they cannot be followed with mathematical accuracy—they are rather subjective in that they permit many variations.

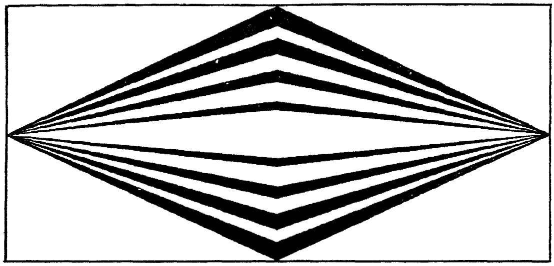
A careful study of nature and natural laws reveals the order which exists in the universe and in all of nature about us. A designer may take, as his point of departure, some of the inanimate forms such as a snowflake, or some forms of plant and animal life. "A study of design is, therefore, first of all the study of 'order' in terms of beauty" (30-18).

Types of Design.—There are four general types of design: (1) naturalistic, (2) conventional, (3) geometrical, and (4) abstract. Naturalistic design arises from natural representations of plant and animal life with slightly modified lines. Naturalistic ornaments may be adapted to the other types of design. If, however, they do not conform to the structure of a design and unite with it completely, they are out of place. Conventional design is developed from naturalistic design or from natural forms by simplifying the representations in terms of symmetrical and radial lines. Geometric design is developed from the simpler geometric forms: square, triangle, and circle. The material follows the pattern of the geometric figure and is tied together in such a manner as to form a unified whole. Abstract design is developed or created design from simple lines and area forms. These lines and areas become predominantly vertical, horizontal, or diagonal. As such they reach a point of significance which determines the character of a design. It is these last two types of design which have a direct application to plastics.

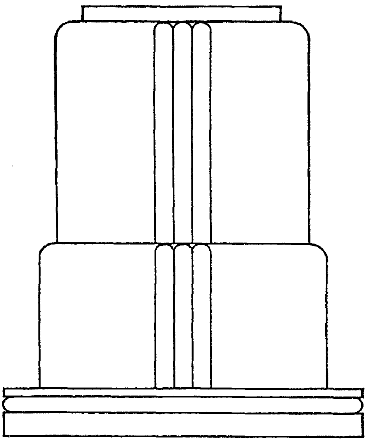
Modes of Design.—There are four modes of design which express the "order" just mentioned: (1) repetition, (2) variety, (3) sequence, and (4) balance. Repetition is, perhaps, the expression of design easiest



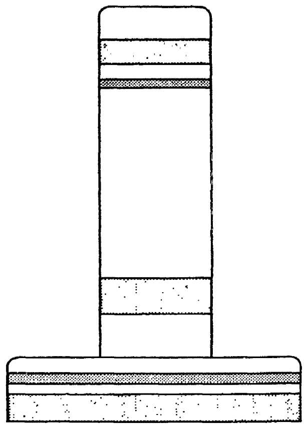
Repetition — Shape and Direction



Sequence



Balance of Thrusts
(Vertical and Horizontal)



Balance of Tone

Balance

Figure 115.. Modes of design.

to understand and use; it consists of the elements of uniform shape and direction. Primitive people commonly express themselves through repetition. Nature provides many examples of repetition. A series of flutes or beads on a lamp column or base, or a series of bands of inlays on a paper weight, furnish other examples of this mode of art expression, providing order and harmony. Repetition, if carried too far, tends toward monotony. Variety, combined with repetition and balance, relieves monotony, provides interest, and achieves "order in complexity."

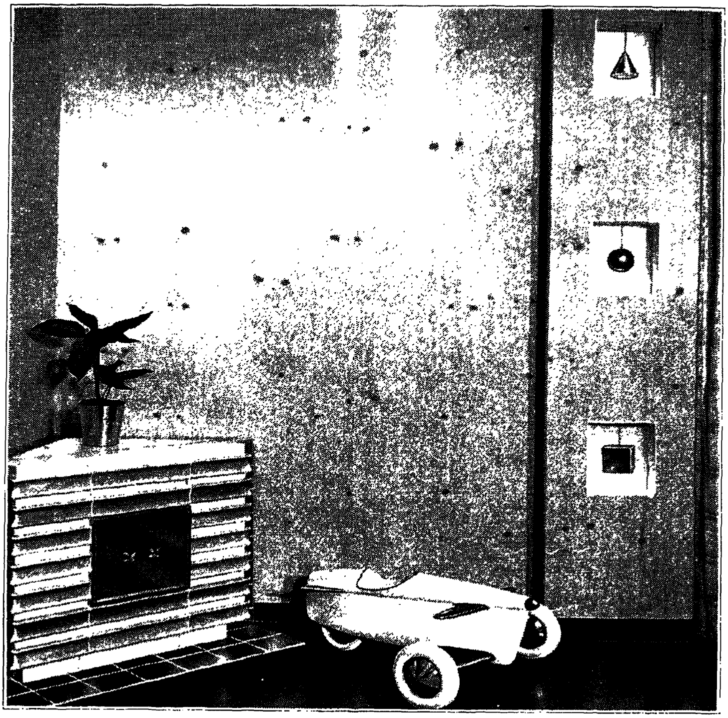
Sequence may occur alone or in combination with repetition or balance. It provides the dynamic or active touch to design—it lends variety. The change which occurs is a systematic, orderly one. It tends to relieve the monotony of too much repetition and provides interest.

Balance is that factor of design which tends to hold all parts of the design together in equilibrium by providing "an equal opposition of forces." A well-balanced design gives an appearance of stability rather than readiness to tip over at the slightest provocation. If function demands a large mass at the top of an object, additional mass is worked into the design somewhere else so that the object does not look top-heavy. Varnum suggests four types of balance (83-59): balance of thrusts, balance of tone, balance of space and mass, and balance of color. The latter two types of balance will be discussed later in this chapter.

A successful designer leans heavily upon balance because he can thereby determine proper amounts of repetition and sequence. Symmetrical design occurs when two halves of an object carry the same shape on opposite sides of a center line. A dining-room table, a tree, an automobile viewed from front or back, and a sugar bowl, are examples of symmetrical balance. In the case of asymmetrical balance, like shapes do not occur on both sides. However, the parts of an object are so placed as to give an observer a feeling of equilibrium. While *symmetrical* balance is an easier type to manage, *asymmetrical* balance is often used to provide a more subtle design.

Division of Design Elements.—In any object there is a certain amount of solid material. A box blocks out all of the open space which is consumed by the object. Many objects, however, are designed with

considerable open space around the solid or blocked-in parts. Elements in any design should be carefully *proportioned* as well as balanced. It is not advisable to cut a design into equal parts of open space and solid elements. *Nearly* equal proportions indicate just as poor taste.



(A Robert M. Damora photograph. Courtesy of the Monsanto Chemical Co.)

Figure 116. Geometric forms and cabinet decorations for child's room (cast phenolic) designed by Raymond Loewy.

(*a*) *Geometric Forms.*—A brief consideration of the simple geometric forms which provide the basis for all geometrical design may help the reader in understanding the fundamental principles of space and mass division. A *square* is a static figure which does not arouse interest. It possesses the element of finality and does not invite a shifting of attention. Cubes, octagons, and rectangles may be developed from the square. A *triangle* provides the structural background for

hexagons and pyramids. A *circle* seems quite sufficient within itself. Cylinders, spheres, cubes, and cones are geometric solids developed from the three plane forms. Variation of a circle is practically impossible unless the vertical and horizontal axes are made unequal in length, when the figure is, of course, no longer a circle.

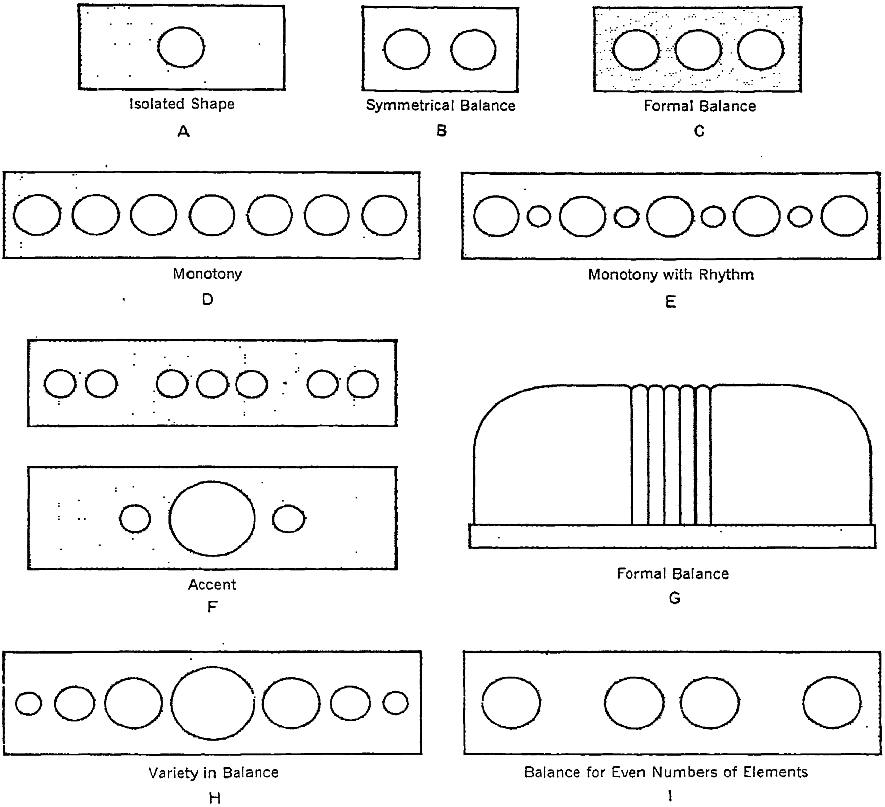


Figure 117. The development of formal balance.

Let us proceed, by the use of simple plane figures, to develop the principles of accent and rhythm in their relation to balance. In Figure 117 a white circle is used as the design form. A single circle is an isolated shape with little meaning. When two circles are placed close together, balance is achieved, but interest tends to shift from one to

the other as it did between many of the wallpaper designs used a few years ago. When three circles are placed together, *formal balance* is achieved—the eye can rest easily on the center circle. When several circles are placed close together in a straight line, a monotonous arrangement occurs.

Perhaps five is the greatest number of elements which should occur together in repetition in a design. When seven or more are used together, they are difficult to see as a unit and that fact annoys an observer. In no case should an even number of elements be used with equal spacing, for the difficulty is the same as in Figure 117 (B). *Rhythm* in design is achieved by varying the size or tone of the elements. *Accent* is made possible by changing the size of groups of elements or by varying the size of elements themselves. In Figure 117 (G), a series of five vertical beads is grouped in symmetrical balance at the center of the design form. A horizontal thrust at the base balances the vertical thrust of the beads.

These principles have a very direct application to the development of a design in plastics. When elements of a design such as beads, flutes, laminations, and bands of inlay are employed, an even number in repetition is never used (see the laminated rings in Plate 1). When function demands four or six like elements, balance may be achieved by grouping two or four elements in the center more closely together and leaving an extra space between the center group and the outer groups.

(*b*) *Rectangle.*—As has been said before, a square is a static figure and rather uninteresting. By varying the length of two of the sides, however, a number of very interesting rectangles may be developed. A study of Figure 118 will reveal the place of this geometric form in design. The form in Figure 118 (B) is technically a rectangle because its horizontal length is slightly greater than the height, though the difference is small. Except under careful observation, the figure has the appearance of a square. It has, therefore, retained its original fault. This rectangle lacks character and provides little interest for an observer. This change from the static form has made little improvement from a design angle and should be disregarded.

A series of rectangles may be developed geometrically from a square by drawing a diagonal of the square and revolving this diagonal to the

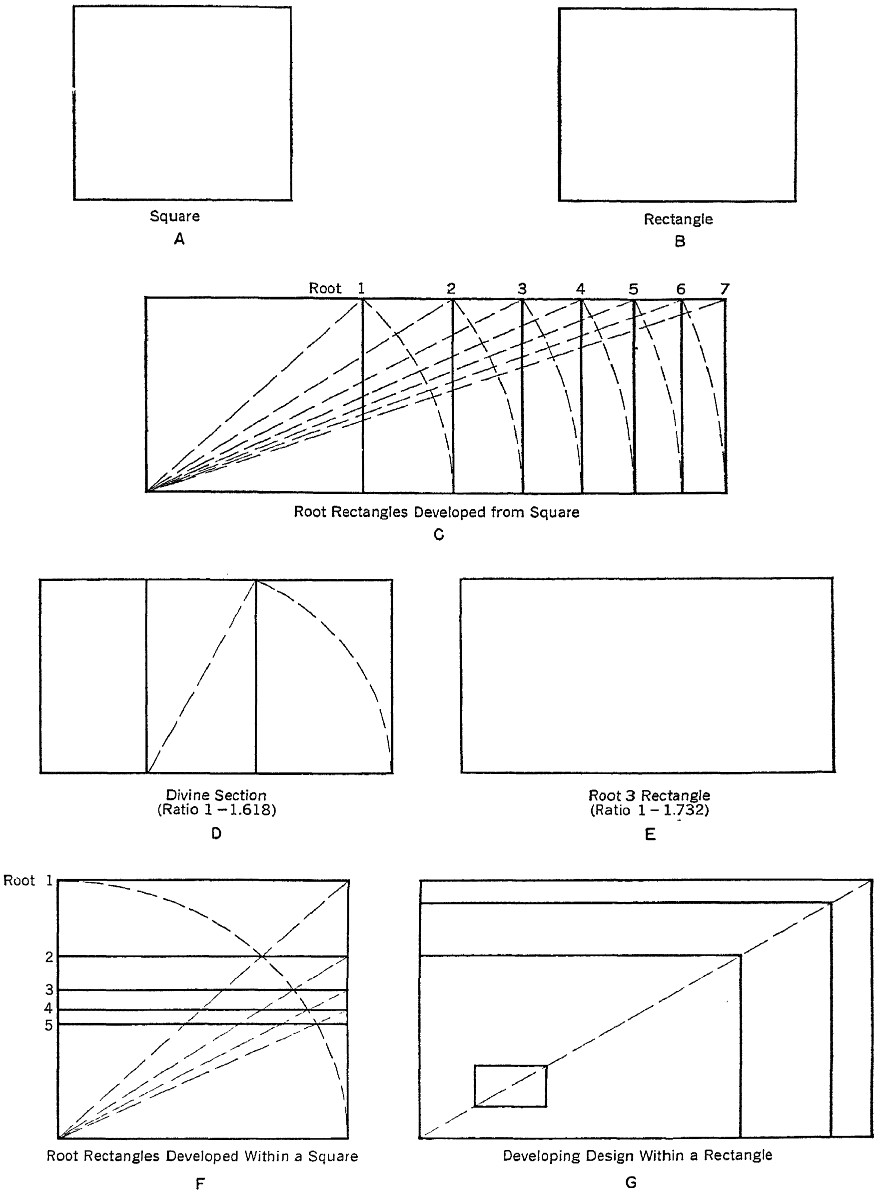


Figure 118. The Rectangle in design.

horizontal or vertical to produce the other dimension of a rectangle. Successive rectangles are produced by using the diagonal of the first rectangle for the length of the second, and so on. Rectangles developed in this manner are known as *root rectangles* or as *Hambidge rectangles* after Jay Hambidge, who rediscovered them and found many applications of them in early Greek and Egyptian design. These rectangles are of value in developing proportions of blocked-in or over-all areas.

The root-two rectangle has a ratio of 1 to 1.414, the root-three rectangle a ratio of 1 to 1.732, the root-four rectangle a ratio of 1 to 2, and the root-five rectangle a ratio of 1 to 2.23. Of this series, perhaps the root-three rectangle presents the most pleasing proportion and the root-four rectangle the least pleasing because the ratio is a double. Therein lies a fundamental principle of design. *Any design which includes cutting elements or space in halves is poor taste.* An extension of the series of root rectangles to root-six and root-seven rectangles presents a condition not pleasing and should be used only when function demands it.

Another interesting rectangle is known as the "whirling square" or the "golden oblong" [See Figure 118 (D)]. This rectangle is constructed from a square by drawing a diagonal of one-half the square and adding the dimension to one-half the side of the square to form the length of a rectangle. This procedure produces a geometric figure having a ratio of 1 to 1.618 and is presented by designers as being the "most completely satisfying of all rectangular shapes." This and other rectangles are used in design to enclose a space into which all subdivisions or details are placed.

Rectangles may not only be developed from a square where one side of the square is used as the short side of the rectangle, but they may be developed within a square with a side of the square equaling the long side of the rectangle [See Figure 118 (F)]. Once a rectangle of desired proportion is secured, details can be developed within the enclosed space by using a diagonal as in Figure 118 (G). Plastics surface decoration and enrichment may be located in this manner.

(*c*) *Division of Rectangles.*—Rectangular masses are commonly divided into design elements. One would not divide a rectangular mass into two equal parts, for he would have a condition similar to that of

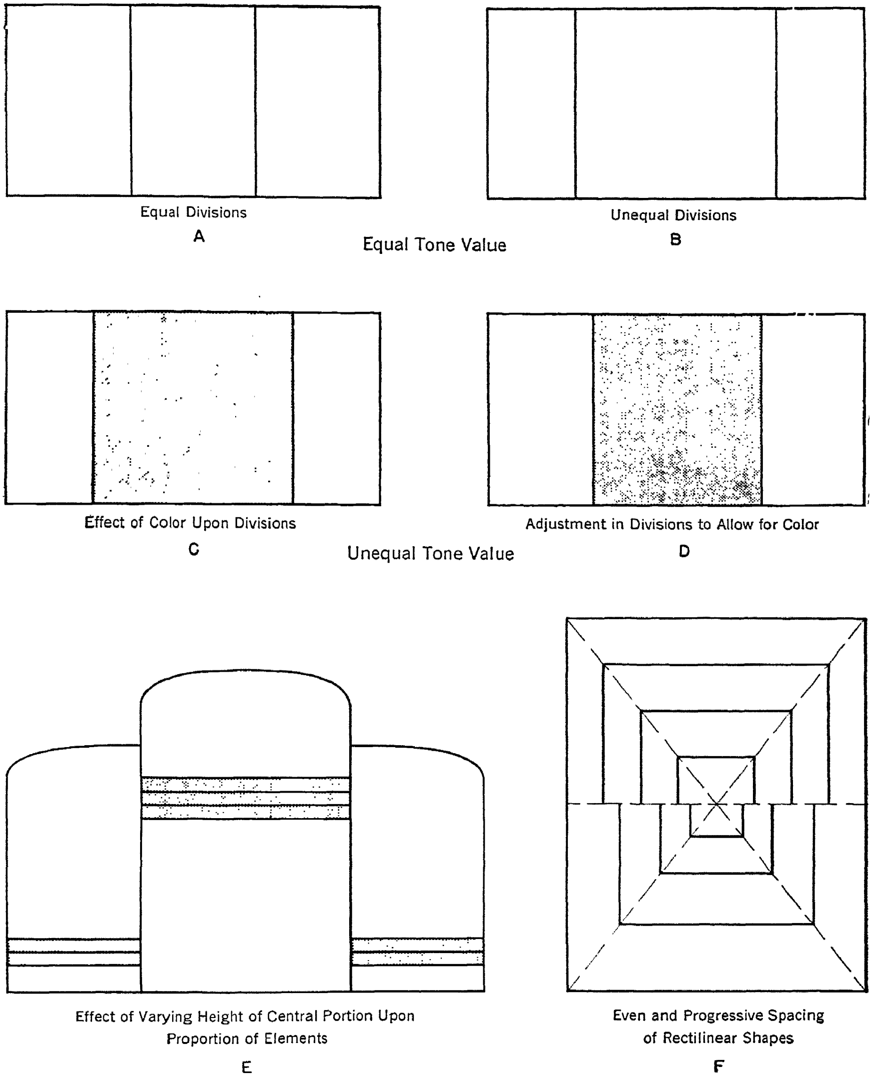


Figure 119. Division of space and mass.

the two circles in Figure 117. Three divisions, therefore, are commonly used. Rather than make these divisions equal in size they are made definitely unlike as in Figure 119 (B).

Proper balance of these elements should be left to the judgment of a designer. One who would be proficient in this art should study many forms and proportions so that his eye can be relied upon. If additional area is added to the central element by adding height, for example, then the outer elements must be increased to compensate for the change. The reader will note that the outer elements in Figure 119 (B) are slightly *less* than one-fourth the width of the whole mass. In Figure 119 (D) the outer elements are slightly *more* than one-fourth the width of the whole mass. This proportion is carried to Figure 119 (E) when the variation is in *area* rather than tone.

Several factors, such as color, texture of finish, materials, and height of the central element influence the comparative relationship of design elements. A dark color tone in a central element demands an increase in the size of the outer elements, as in Figure 119 (D), to secure balance. If the dark tone is to be used in the outer elements, the central element should be increased in width.

There are many occasions for using diminishing rectilinear shapes in the design of plastics. Covers for boxes, bases for lamps, and desk pens where setbacks are used, present opportunities for principles of design. Even spacing of the elements offer a less interesting treatment than does *progressive* spacing, as in Figure 119 (F). If the reader cannot rely upon his eye to give the proper size to each progressive step, root rectangles may be used for determining the size geometrically. Construct a series of rectangles basing each one upon a diagonal of the preceding one as described above.

A designer may, by skillful treatment, cause a design or object to look like something which it is not. Dress designers use vertical stripes to give a stout person added height rather than horizontal bars or large naturalistic designs, which tend to accentuate an already large size. Two rectangles equal in size and placed alongside each other will appear widely different if one has a distinct horizontal center line and the other a distinct vertical center line. If, in a vertical mass, an element is placed in the exact geometric center, the eye sees it below

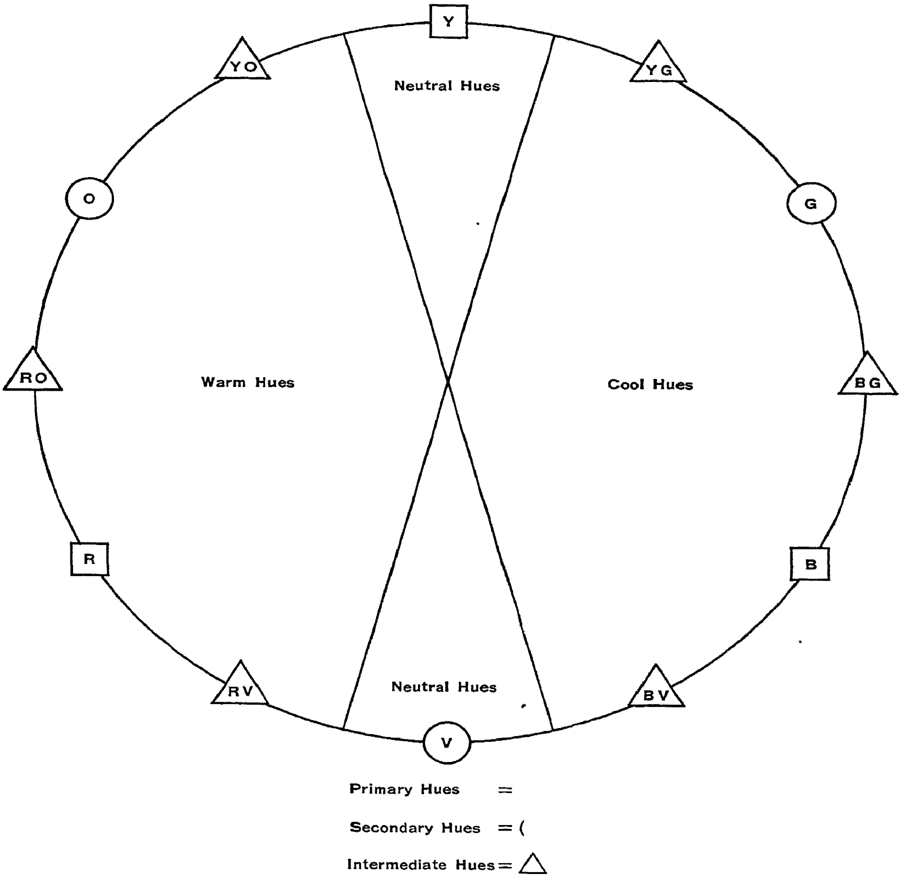


Figure 120. Chart showing primary, secondary, and intermediate hues.

the center. An adjustment in the design must compensate for this illusion (see Plate 39). A narrow,, dark band at the base of a tall, unstable design will give stability to the design.

Color.—An extensive use of color has developed since the close of World War I due to the necessity of providing a stimulus for industrial and commercial growth. Dull, drab articles were replaced with colorful merchandise to attract buyers. Another spurt in the production of colorful goods came after the first period of the depression of the early thirties.

Conditions in which we find ourselves demand that *Mr. Average Consumer* have some knowledge of *color*. It is true that there are few artists who know all of the ramifications of color and who can use it as an instrument to produce pleasing results in a variety of circumstances, but anyone with sound intelligence and eyesight can, by careful study, acquire sufficient knowledge to enable him to be a successful consumer of colorful merchandise.

(*a*) *Properties.*—Three properties are recognized in any color tone: (1) value, (2) hue, and (3) intensity. When a color is viewed, the first thing which strikes the eye is the quality of the light reflection—the *hue*. This quality tells us that it is green or yellow. Hue, therefore, is the same as a common color name. *Value* refers to the amount of lightness or darkness in the color. Light yellow, dark purple, and medium blue refer to value. *Intensity* refers to purity or strength of color, as a grayed or a weak color.

Several additional terms must be understood before one can speak or read intelligently on the subject of color. There are three primary color hues, each of which is not made up of any other hue: red, yellow, and blue. When the primary hues are combined in equal portions, three secondary hues are produced as follows:

Red and yellow = orange
Yellow and blue = green
Blue and red = violet

A further combination of these six colors with each of the others in various proportions produces the intermediate hues.

Color affects our feelings more than most people realize. "Warm" colors suggest strength and weight as well as higher temperatures. "Cool" colors suggest the opposite. White suggests cleanliness. Grayed values of blues and greens suggest dignity. The intense tones of the warm colors give the opposite feeling. This may explain the reason for the color selection upon children's toys, sports clothing, and sport automobiles, as contrasted with the color selection on limousines, evening clothing, and formal gowns. A color hue is only good or bad as it is used correctly or incorrectly in combination with other hues. Black has a depressing effect when used alone, but it is used

on many pieces of merchandise effectively, as bands on stoves, refrigerators, and furniture.

(*b*) *Color Schemes.*—Even though each color hue is delightful in itself, a more artistic effect may usually be obtained by the addition of one other hue and, at times, two additional hues. The colors must, however, harmonize—they must not clash or fight each other. Color harmony is achieved by combining *near hues* with a body color for variety. These near hues may be determined by moving from any hue on the color chart not more than two hues to the right or left. Accents and sparkles can be added by small areas of a complementary hue (that directly opposite on the color chart). Equal masses of two colors produce an undesirable effect.

White and black may be used successfully with any other color, but together it takes a skilled artist to secure pleasing results. Varnum (83-142) quotes Frankl on pleasing color schemes:

"Red—white, yellow brown, orange
Orange—white, red, brown, yellow
Yellow—white, brown
Green—white, yellow, red, blue, brown, black
Blue—white, black
Purple—white, red, blue, black
Gray—all colors, including white
Black—all colors except white"

These color schemes may be used to secure harmony with plastics inlays on body colors. Likewise other surface and plastic enrichment offer splendid opportunities to use pleasing color schemes. Carved or recessed designs may be enameled to secure interesting effects. Avoid the use of intense colors when dignity is desired.

SUMMARY

In order that the principles of design for plastics may be more closely knit together for readers, the following summary has been prepared:

1. Plastics must be thought of as an individual structural material with its own peculiarities and must not be treated like other media of practical arts merely because it can be fabricated with some

of the same tools. The material has a texture, a finish, a color, a specific gravity, a hardness, and a machineability of its own.

2. Since plastics is available in a variety of forms (cast, laminated, and molding compounds), it behooves a designer to adapt one of the forms of plastics to each particular *function*. The design to meet the function should then be influenced greatly (but not dictated entirely) by standard sizes and shapes.

3. Geometric area forms, rectangles and ellipses which are derived from the simpler geometric shapes, form the basis for most plastics designs. Economy of material should govern ornamentation embodied in the design.

4. Color, an asset of plastics, should be used to brighten less colorful furniture and home decorations. Combinations of near hues and small areas of complementary color should result in a harmonious use of color in any design. Color in plastics design should also blend with the surroundings.

5. To assist in developing plastics design, working drawings have been provided in the following chapters. These should provide the necessary help in establishing proportions for the mass of an object. Since some dimensions are omitted, division of certain areas provide an opportunity for the worker to use the principles of design in establishing the balance of required dimensions.

6. Many additional ideas are suggested through the following plates. They are in the form of undimensioned sketches which may or may not be accompanied by a working drawing of a similar object. The development of area forms and dimensions is, therefore, left to individual initiative.

Chapter 8

Handwork Problems

BEGINNERS IN EVERY CRAFT must have some point of departure from which their ability and interest may grow. It would seem that the most practical starting point would be on problems involving handwork. Several such problems are herewith suggested.

The thirty problems which follow have been arranged in five groups according to the quantity of plastics used and to the order of difficulty. Even though economy of material is observed in all problems, the designs for the first two groups are held to a minimum of material. There are involved in the early problems in this chapter the fundamental operations of laying out, sawing to shape, surfacing, and finishing. Operations of drilling, tapping, inlaying, overlaying, joining, cementing, carving, and engraving are introduced with later problems.

Hand operations may be used in completing each problem outlined, although a jig saw, a drill press, a disc sander, and a polishing head may be used to advantage on most of the exercises. These problems have been designed for the benefit of those laboratories with no machine equipment, but they need not be limited to this group of laboratories.

As a craft worker progresses in accumulating experiences with plastics materials, he will begin to see ways of varying a design to reflect his own personality. Designs for new problems and companion pieces for some of the problems suggested on the following pages will begin to take shape in his mind. It is by this procedure that creative talent may be aroused in those who contact this book. Any deviation, however, from working techniques found to be successful should be carefully analyzed and attempted on a small scale.

There is an excellent opportunity to develop the art of color selection, since spectral and pastel shades of color from crystal to opaque

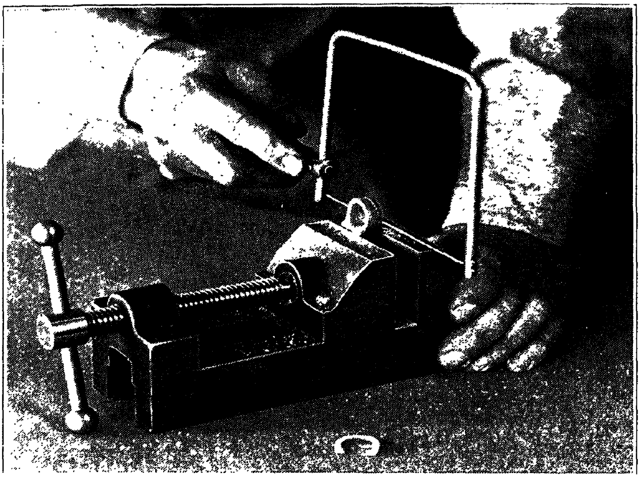


Figure 121. Shaping ring blanks.

Figure 122. Ring buffiing equipment.

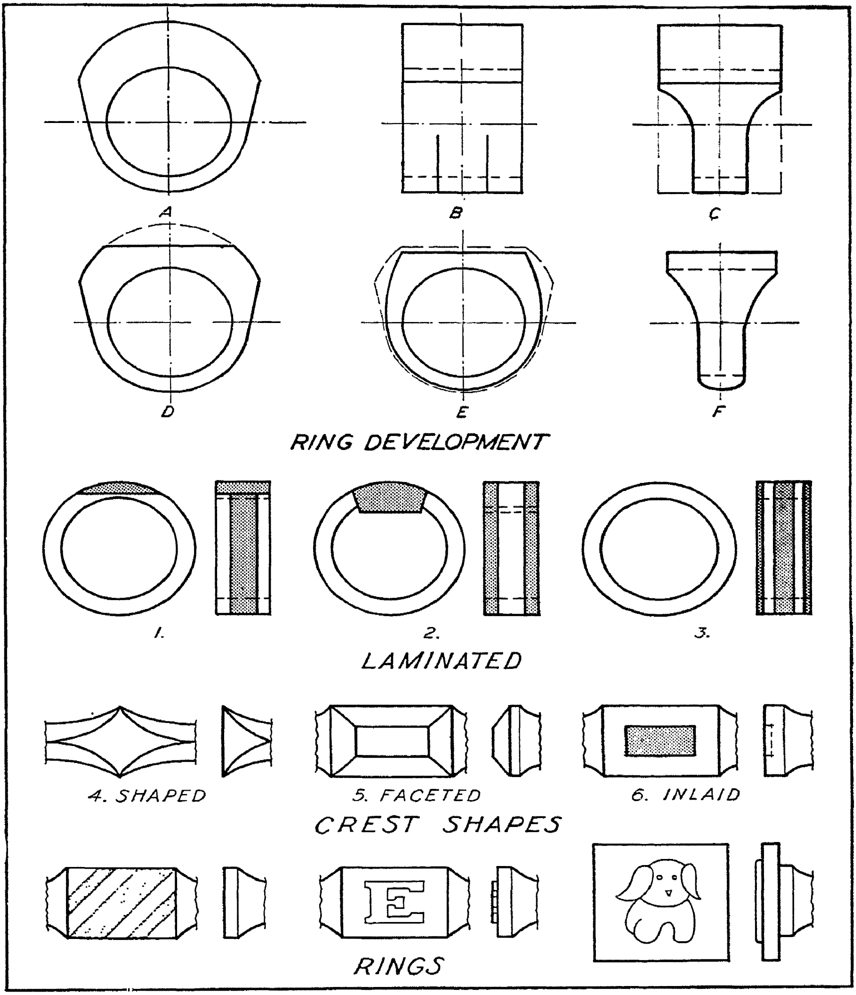

A
B
C
D
E
F
RING DEVELOPMENT
1.
2.
3.
LAMINATED
4. SHAPED
5. FACETED
6. INLAID
CREST SHAPES
E
RINGS

Plate 1

black are available in cast plastics. Articles may be made, therefore, to blend with any surroundings. There is in many cases, furthermore, an opportunity to include two or more colors in the same problem. If there are no separate pieces to provide an additional color, inlays and overlays may be added to provide variation.

Care should be taken to select colors which harmonize. There are no specific suggestions for definite colors in any problem following. This selection is left to individual users. Several pleasing color combinations are suggested in Chapter 7. A few combinations of common plastics colors may prove helpful. They are: natural onyx and cloudy amber, cloudy amber and black, green quartz and blue quartz, emerald green and green quartz, rose quartz and cloudy ivory, natural onyx and turquoise, green quartz and natural onyx.

Plate No. 1

RINGS

Rings in a variety of colors and shapes may be made from plastics. Ring stock may be secured in two shapes: special ring castings as shown in Plate 1 under *Ring Development* and in plain tubes with a wall thickness of approximately $\frac{1}{4}''$. Since the special casting is partially shaped, shaping operations are less difficult than on a plain tube.

The initial steps in shaping ring blanks are generally the same. Secure a ring blank and mark it with a pencil as in *B*. Figure 121 illustrates shaping with a coping saw as in *C*. The remaining steps may be completed with files and abrasive papers.

Laminated rings may be made from thin sheet plastics. Celluloid and lumarith sheets may be used, or equally good results may be attained by using old tooth-brush handles, mirror backs, and combs. In the latter case, acetate cement may be used for softening and cementing the layers in place. Note that the laminated sections are not divided into halves. In ring 1 the outside layers are equal but less than one-half of the center. In ring *2* the outside layers are equal but more than one-half of the center. The same may be said of ring 3 (see Chapter 7). A few other shapes are suggested, but ring design is limited only by the worker's ability and imagination.

Another type of ring suggested in *4* and *5* can be made when a minimum amount of equipment is available. Rings thus shaped from one piece of material eliminate the necessity of cementing parts. Tops with facets of many shapes can be easily constructed by the use of a file and abrasive papers. Ring *6* lends itself to the use of various type of inlays. Thin plastics may be used in interesting color combinations The last three designs offer a variety of suggestions where mor special tools are at hand. Overlay or inlay designs may be added tc suit the worker's ability and imagination.

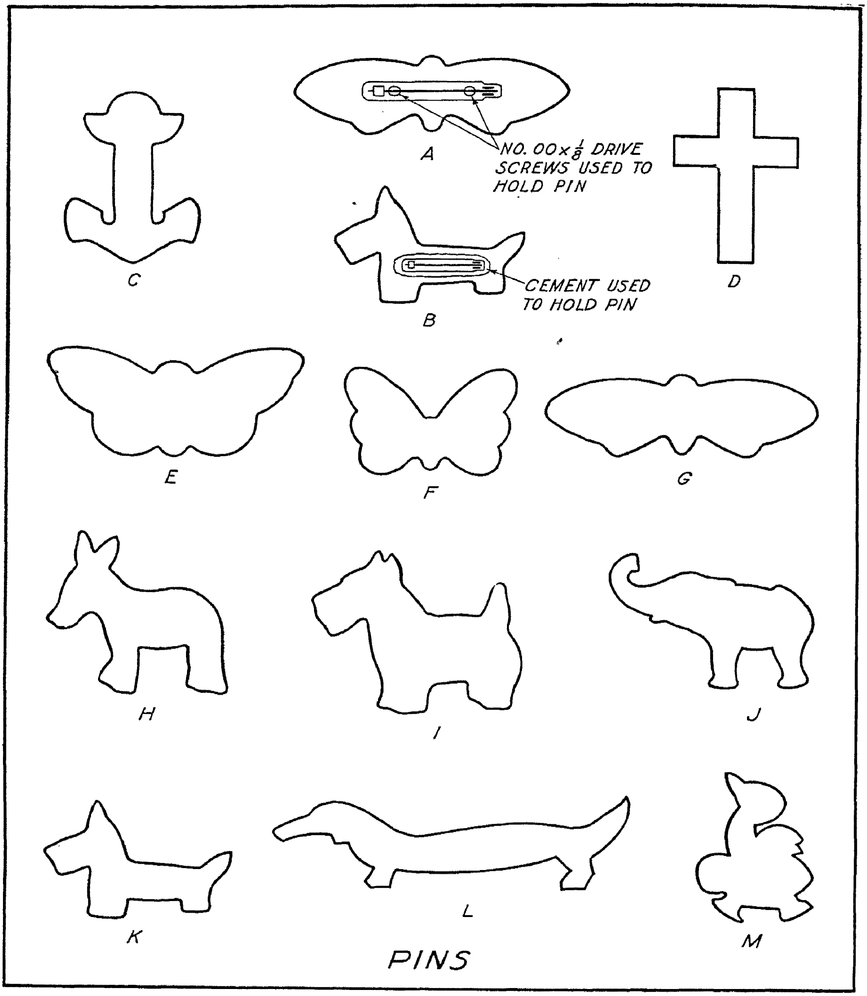

NO. 00×$\frac{1}{8}$ DRIVE SCREWS USED TO HOLD PIN
A
C
D
CEMENT USED TO HOLD PIN
B
E
F
G
H
I
J
K
L
M
PINS

Plate 2

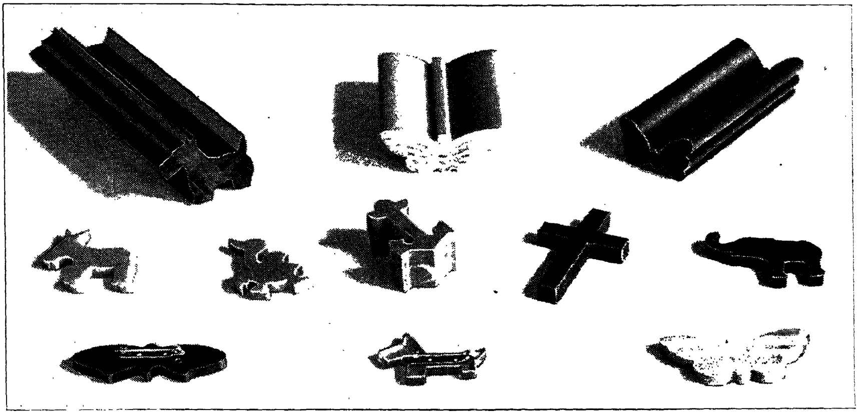


Figure 123. Animal shapes of cast resinoid.

Plate No. 2

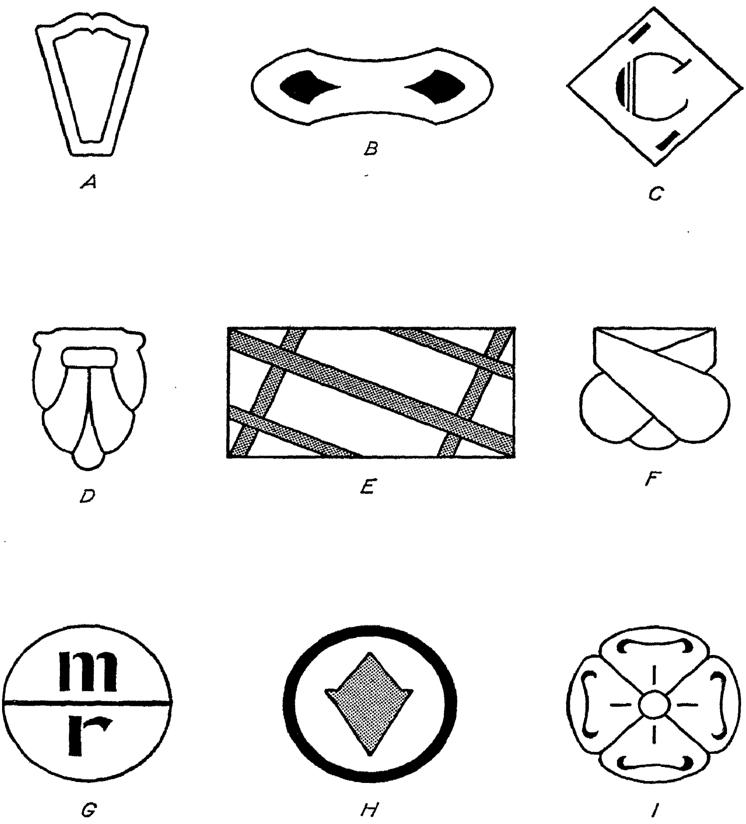
PINS

Pins, as illustrated on Plate 2, are available in many special cast forms. A few of these special shapes are shown in Figure 123. Thin slices should be cut with a miter saw. For production work, a band saw is ideal if available.

If drive screws are to be used to fasten pins to the plastics, the sections should be $\frac{3}{16}''$ to $\frac{1}{4}''$ in thickness. Plate 2 (*A*) illustrates this method of assembling. See Table V for proper drill size.

Another method of securing pins to plastics is by using adhesive cement. Plate 2 (*B*) illustrates this method. When cement is used as a fastening agent, the back of the pin should not be polished where cement will be applied. Slices thinner than $\frac{3}{16}''$ may be used when pins are fastened with cement.

Many of these designs lend themselves to surface decoration, such as figure lines, eyes, and wing decorations on the butterflies. Even the more advanced worker can find an opportunity for enriching the surfaces. The personal value of all pins will depend largely upon the finish given to the plastics. Care should be taken to produce a maximum lustre.



DRESS CLIPS

Plate 3

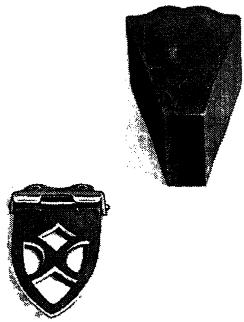


Figure 124. Dress clips (Findings).

Plate No. 3

DRESS CLIPS

Dress clips offer an opportunity for individual ideas to be worked out with a small amount of material and at low cost. Nine suggested designs, all of which can be made from small pieces of scrap material, are given on Plate 3.

Clip *A* may be made from $\frac{1}{8}''$ stock using thin-sheet cellulose acetate for the suggested overlay. A recommended thickness for this overlay is from .010″ to .025″. Shears or tin snips can be used to cut the overlay. In all overlaying operations, care should be taken not to let the overlay slip when cement is applied.

Clip *B* offers two methods for working out the decorative effect. It may be pierced or a thick piece may be shaped and cemented to the surface.

Clip *C* may be carved and a liquid inlay used, or it may be pierced with a fine jeweler's saw. *D* and *F* should be deeply carved and all arrises on the face side rounded to give a padded effect.

Clip *E* should be made with thin overlay pieces while *H* requires two overlays, carefully placed. *G* can be completed by using a thin overlay, or it may be carved and a liquid inlay used. *I* should be carved on all lines and should have all arrises rounded. A liquid inlay may be used for color contrast.

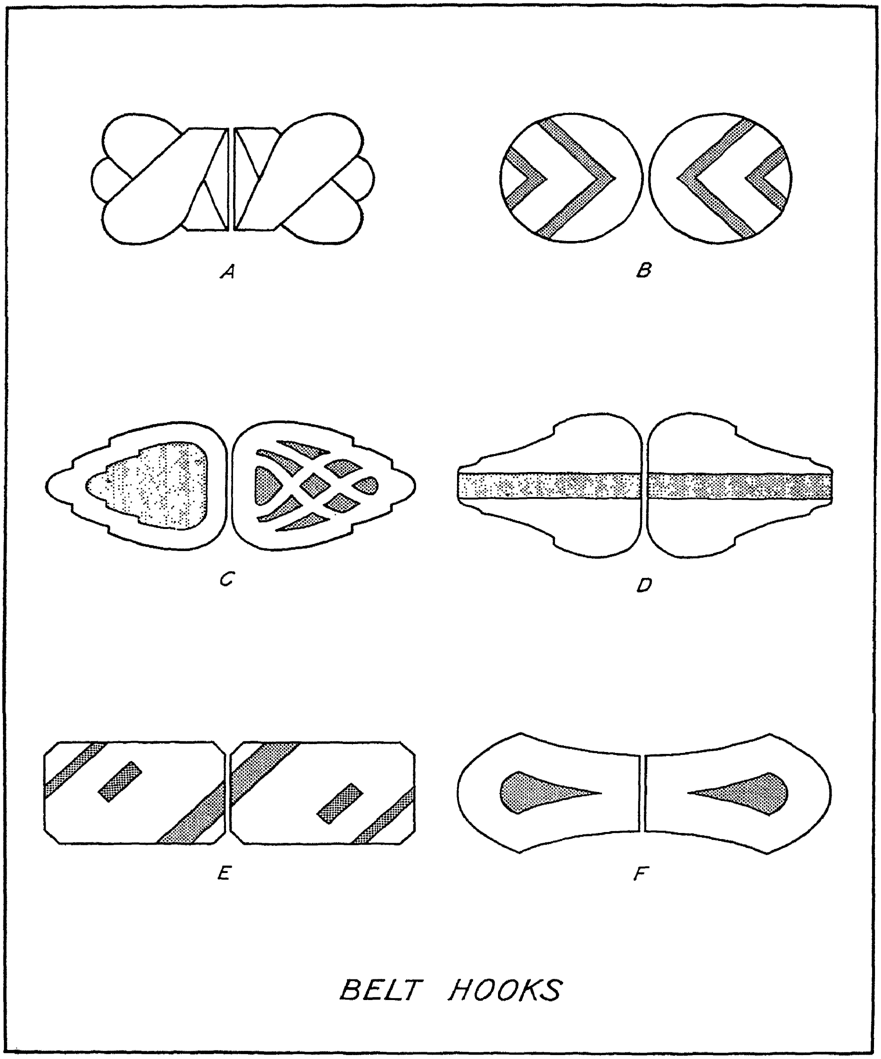


Plate 4

Plate No. 4

BELT HOOKS

Belt hooks offer still another opportunity for individual design. Several suggestions are offered on Plate 4. The design will, however, be governed to some extent by the metal finding used. Models, too narrow, would not conceal the metal hook. Drive screws should be used to hold the hooks firmly in place.

Hook *A* should be carved from ¼″ sheet plastics and should have all arrises rounded with files and abrasive papers. Considerable work should be done on each division so as to give a padded effect.

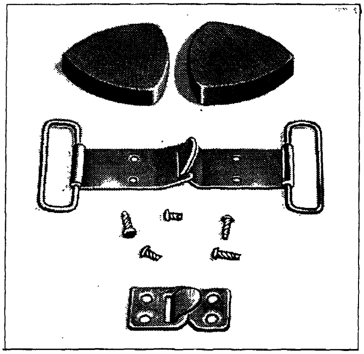


Figure 125. Belt hooks and fasteners.

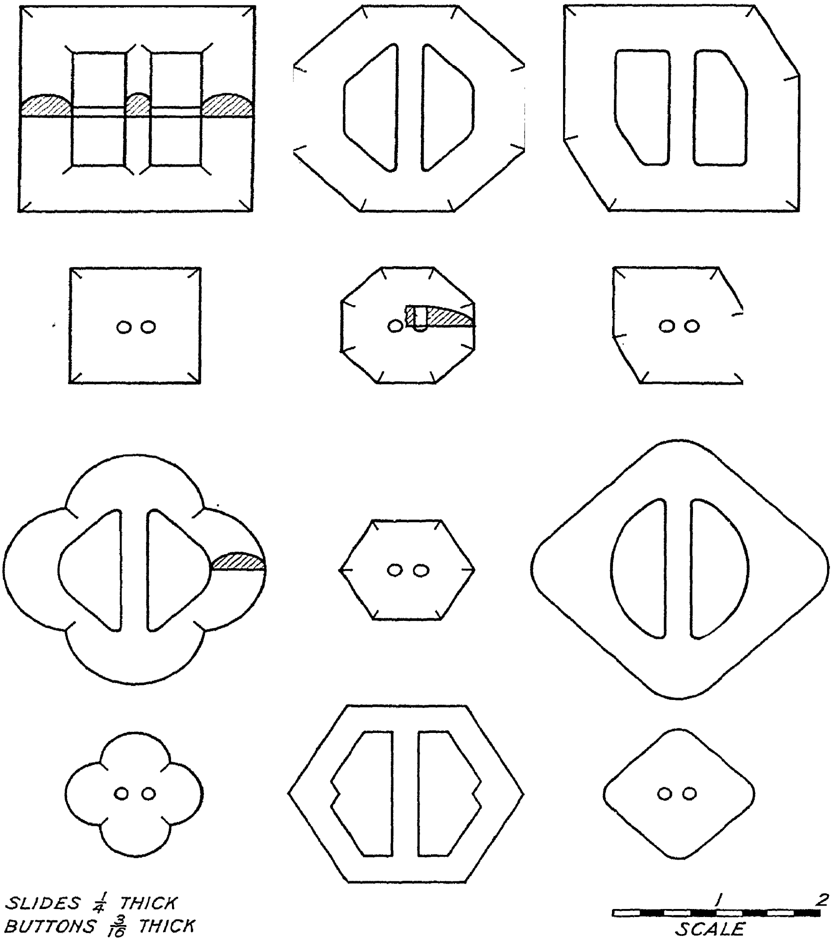
Hook *B* suggests carefully proportioned overlays of thin sheet plastics. The stock in this case need be only thick enough to accommodate the drive screws used.

Hook *C* may be constructed with a single overlay as shown on the left, or sections may be removed from the overlay as shown on the right. If the latter method is selected, the overlay should be cut to shape and carefully laid off before it is cemented in place. The lines should be carefully followed with a sharp-pointed knife. Sections should be removed before the cement sets. Excess cement should be removed and the parts allowed to dry before finishing operations are attempted.

Hook *D* is a simple overlay design that requires little explanation. In Figure 125, several types of belt hooks and fasteners may be seen.

Hook *E* is another overlay suggestion. This time a problem in line and space division is presented. Surface area is divided unequally by lines of varying width and thickness (see Chapter 7).

Hook *F* may be enriched either by an overlay of any desirable thickness or by a pierced design. All forming and shaping marks should be removed before finishing operations are attempted.



SLIDE AND BUTTON SETS

Plate 5

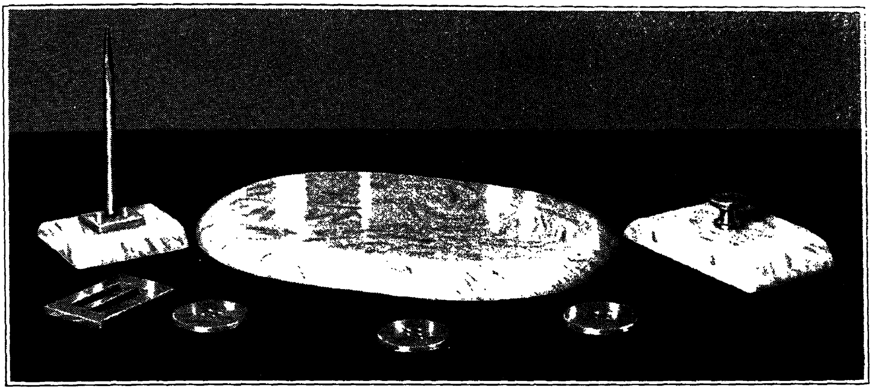


Figure 126. Bill file, paper weight, table center piece, and slide and button set.

Plate No. 5

SLIDE AND BUTTON SETS

The *buttons* illustrated are made from $\frac{3}{16}''$ sheet stock. *Slides* to match should be of slightly heavier material.

The small scale on Plate 5 enables one to acquire the proper size and proportion with the aid of an irregular curve and dividers. When cutting to shape, saw and file the edges square with a face. Holes for the buttons are drilled $\frac{3}{32}''$ in diameter. The space between holes may be lowered with a carving tool, to provide space for thread. Arrises at the front face should be rounded considerably more than those in the back.

Special castings of various shapes and sizes and of the type from which commercial slides are made, may be purchased (see Appendix B). Slides from this type of stock are easily made. A slice of the desired design is cut from the casting and both faces are smoothed. When the arrises are rounded, the article is ready for a buffing wheel.

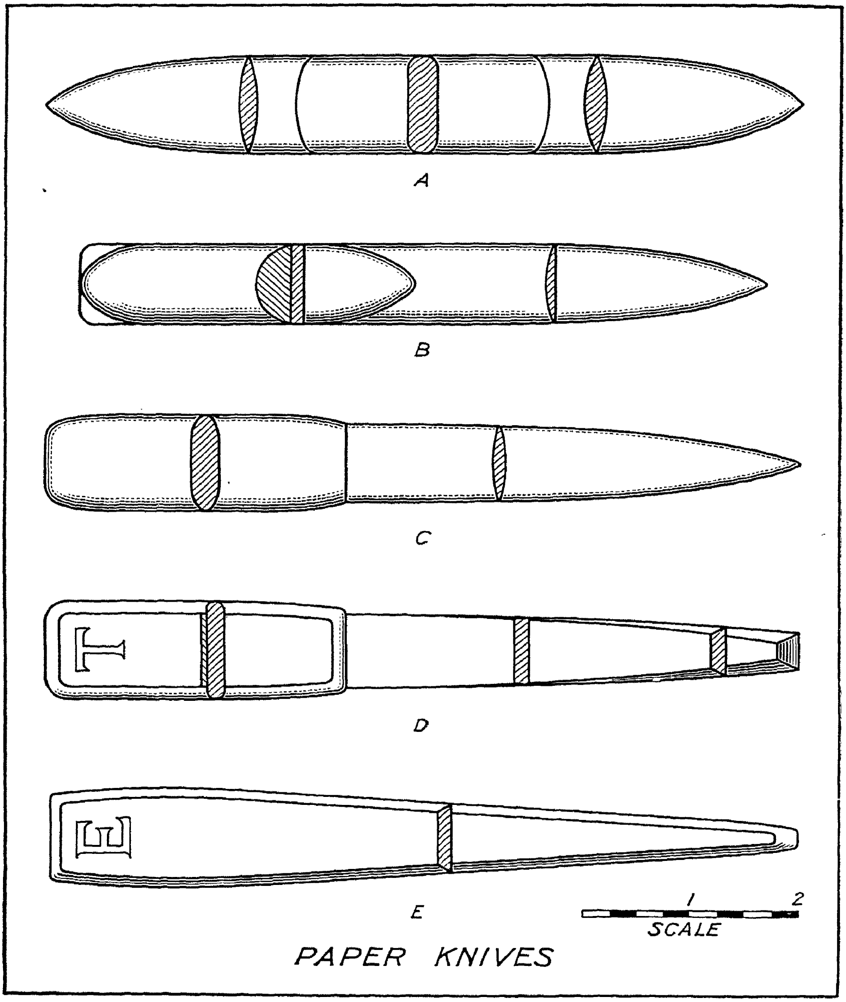


Plate 6

Plate No. 6

PAPER KNIVES

Paper knives are usually made from thin sheet stock and often require much handwork to produce a nicely finished article. Five designs are suggested in Plate 6. A small scale is provided instead of the usual dimensions. In each case, a cross-section view is given to aid in determining the shape and thickness.

Before attempting to make a paper knife of any design a templet should be cut from heavy paper or cardboard. The shape and proportion of the handle and blade should be carefully worked out on the templet before the transfer to the plastics is made. This will eliminate unnecessary laying-off marks which are very difficult to remove.

Knife *A* is made from $\frac{1}{4}''$ material and either end may be used as a knife. In this design, a center section is used for the handle. Files and abrasive papers are used in cutting the ends to the proper shape. All file marks and scratches made by shaping operations should be removed before finishing operations are attempted.

Knife *B* is made from $\frac{1}{8}''$ stock, using a thick piece of plastics for the handle end. This piece may be made by sawing a rod of the proper diameter in the center. It should be made and most finishing operations completed before it is cemented in place.

C is a simple design made from $\frac{1}{4}''$ flat stock. Care should be taken in shaping the handle and the cutting edges of the blade so as to produce even and uniform curves.

Knife *D* varies from the usual type. It is shaped like a bevel-edged wood chisel. A thin overlay of acetate plastics with a pierced initial forms a personal decoration for the handle.

Knife *E* also, is of the beveled-edge type. An overlaid initial may be used on the handle. By using a fine jeweler's saw, the handle may be pierced for an initial. The beveled edges should be carefully shaped before starting finishing operations.

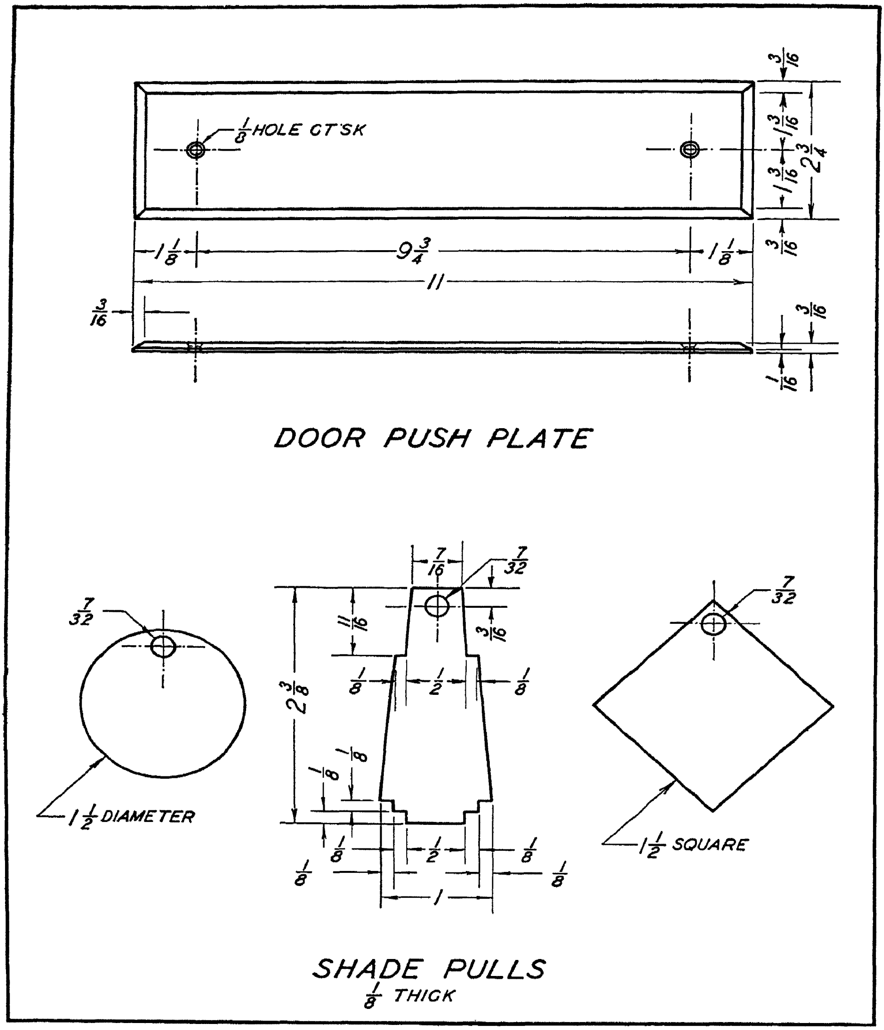

1/8 HOLE CT'SK
DOOR PUSH PLATE
1 1/2 DIAMETER
1 1/2 SQUARE
SHADE PULLS
1/8 THICK

Plate 7

Plate No. 7

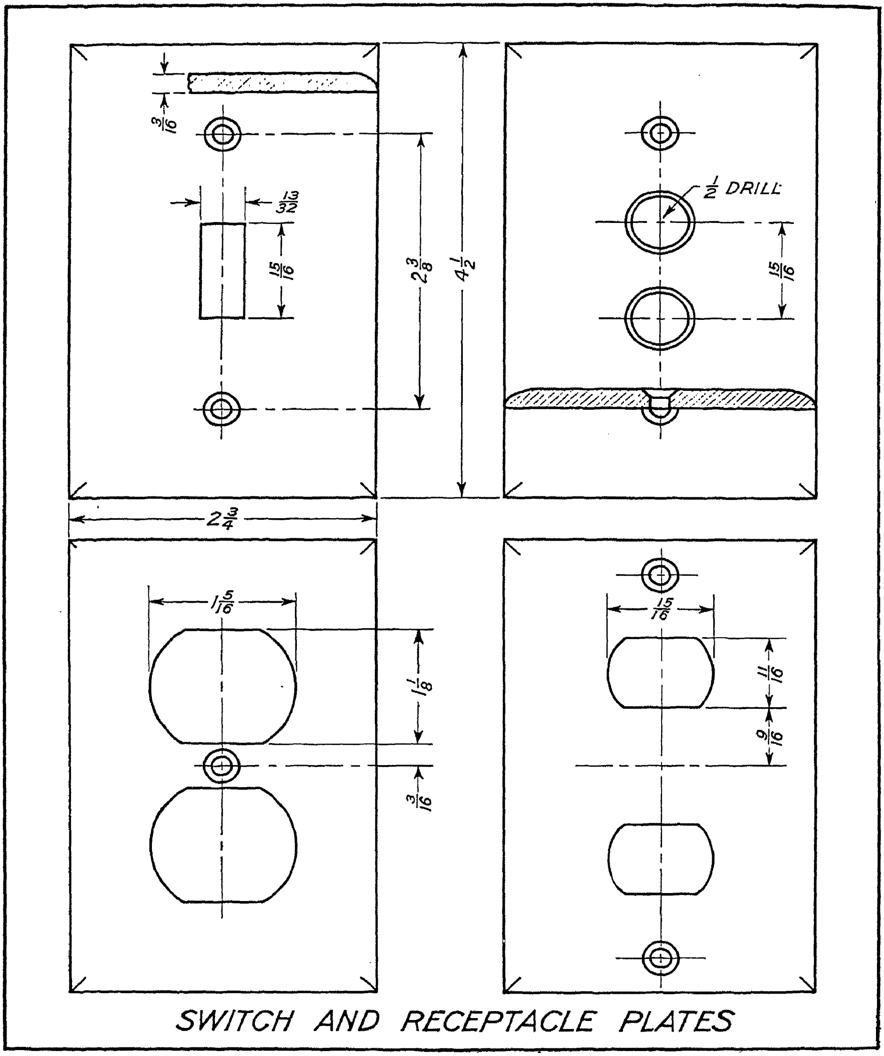
DOOR PUSH PLATE AND SHADE PULLS

Color and utility may be combined in these elementary problems. Modern kitchen accessories often employ the use of plastics to add color and trim to otherwise plain and unattractive material. For additional color, push plates and shade pulls may be designed from plastics to harmonize with a certain color scheme. A minimum amount of equipment is required for the problems suggested.

The *door push plate* is cut from $\frac{3}{16}''$ sheet stock and is shown with a $\frac{3}{16}''$ chamfer on all sides. Holes at the center of each end are drilled and countersunk for $\frac{3}{4}\times 6$ oval-head wood screws of a desirable finish. A more pleasing effect may be produced by substituting an elliptical curve for the chamfered arris. A block plane may be used for producing a chamfer on most cast resinoids (see Chapter 5). Since the surface area in this problem is rather large, care must be taken in the finishing and polishing operations in order to bring out natural beauty in the material.

Shade pulls may be cut from $\frac{1}{8}''$ sheet stock. If available, a $1\frac{1}{2}''$ round rod may be cut into discs in a miter box. This method is more economical, especially if several discs are required. Drilling instructions should be carefully followed on all shade pulls since a chipped hole on either side will show. Narrow strips of sheet stock may often be utilized for pendant-shaped shade pulls. The width and length of offsets may be varied for more pleasing results in formal balance. Another design may be cut from $1\frac{1}{2}''$ square stock using the same method as that used for the round discs.

Other shapes of cast resinoid stock may be used for shade pulls when they characterize the room. Anchors are suggested for the bathroom while animal designs are pleasing in a child's room.



3/16
13/32
15/16
2 3/8
4 1/2
1/2 DRILL
15/16
2 3/4
1 5/16
1 1/8
3/16
15/16
11/16
9/16
SWITCH AND RECEPTACLE PLATES

Plate 8

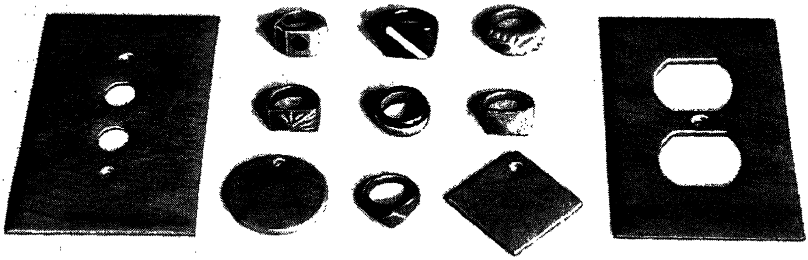


Figure 127. Switch plate, shade pulls, and rings.

Plate No. 8

SWITCH AND RECEPTACLE PLATES

Many of the new type *switch and receptacle plates* are made from molded plastics. These often lack color variation or are made of a dull brown or black hue. Suggestions for switch and receptacle plates are given in Figure 127.

In many instances an old switch plate may be used as a templet for transferring the pattern to a piece of $\frac{3}{16}''$ sheet plastics. If an old switch plate is not available, the dimensions on Plate 8 may be followed. Other sizes and shapes will require different dimensions which may be taken from the electrical outlet itself or from a commercially-made plate. The hue of plastics used should harmonize with other furnishings in the room.

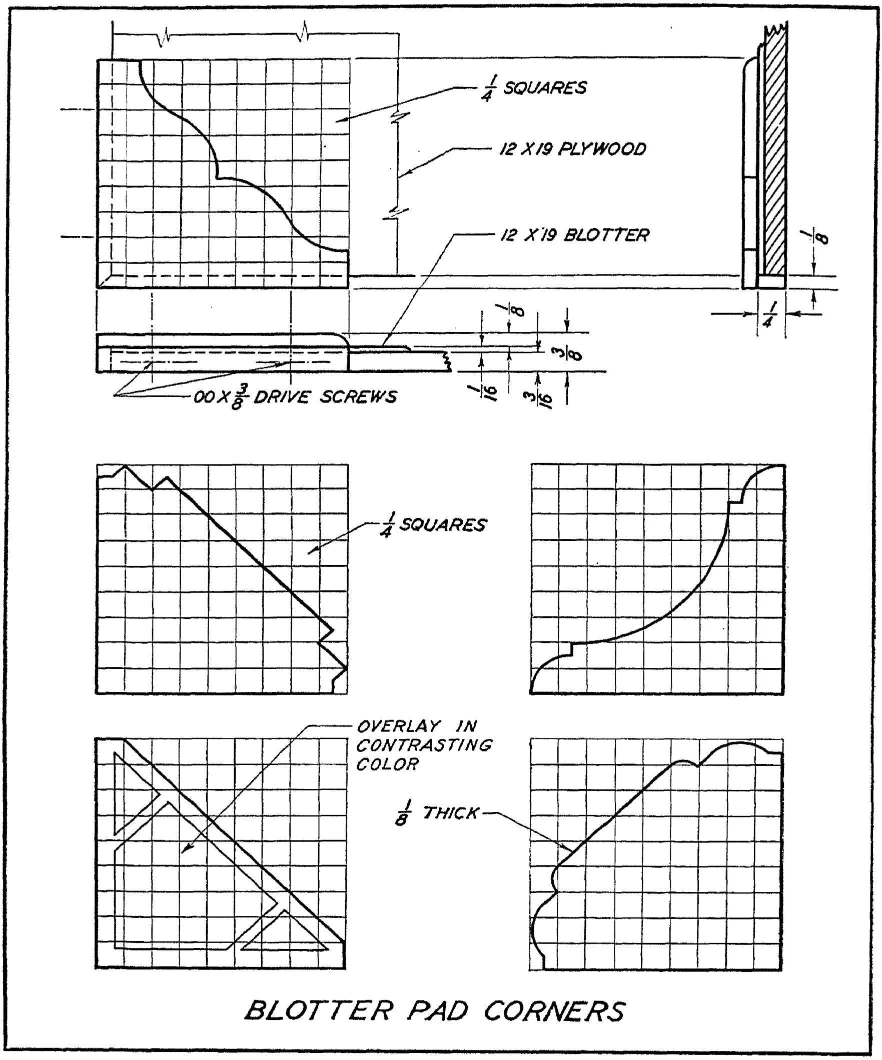

1/4 SQUARES
12 X19 PLYWOOD
12 X19 BLOTTER
1/8
1/4
1/8
3/8
1/16
3/16
00 X 3/8 DRIVE SCREWS
1/4 SQUARES
OVERLAY IN CONTRASTING COLOR
1/8 THICK
BLOTTER PAD CORNERS

Plate 9

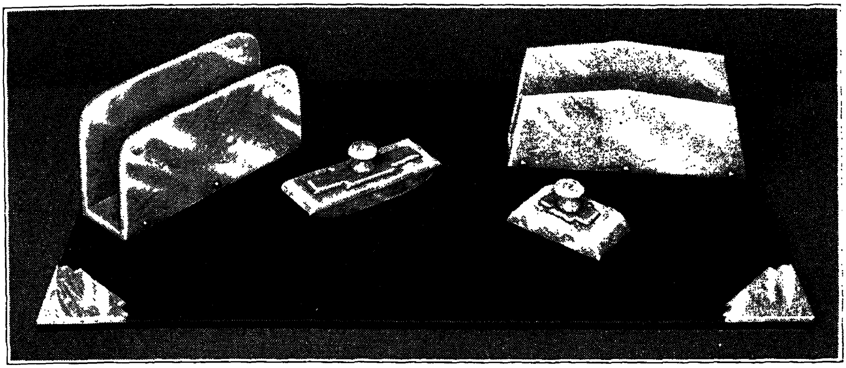


Figure 128. Letter holder, paper weight, desk blotter, and blotter pad.

Plate No. 9

BLOTTER PAD CORNERS

Blotter pad corners are made from $\frac{1}{8}''$ sheet plastics. The base of the blotter pad is made from $\frac{3}{16}''$ pressed wood. This is firm enough to hold drive screws. The piece should be cut to the exact size of a standard desk blotter—common sizes $12'' \times 17''$ and $12'' \times 19''$.

Plate 9 shows corner details when thin plastics strips are cemented under adjacent edges of each corner. Drive screws are used to secure these corners to the blotter base. Another method is that of mounting the corner piece direct to a blotter-pad base with drive screws. If the drive-screw head is not objectionable, the screw may be driven from the top. Screws may be made invisible by driving them from the bottom.

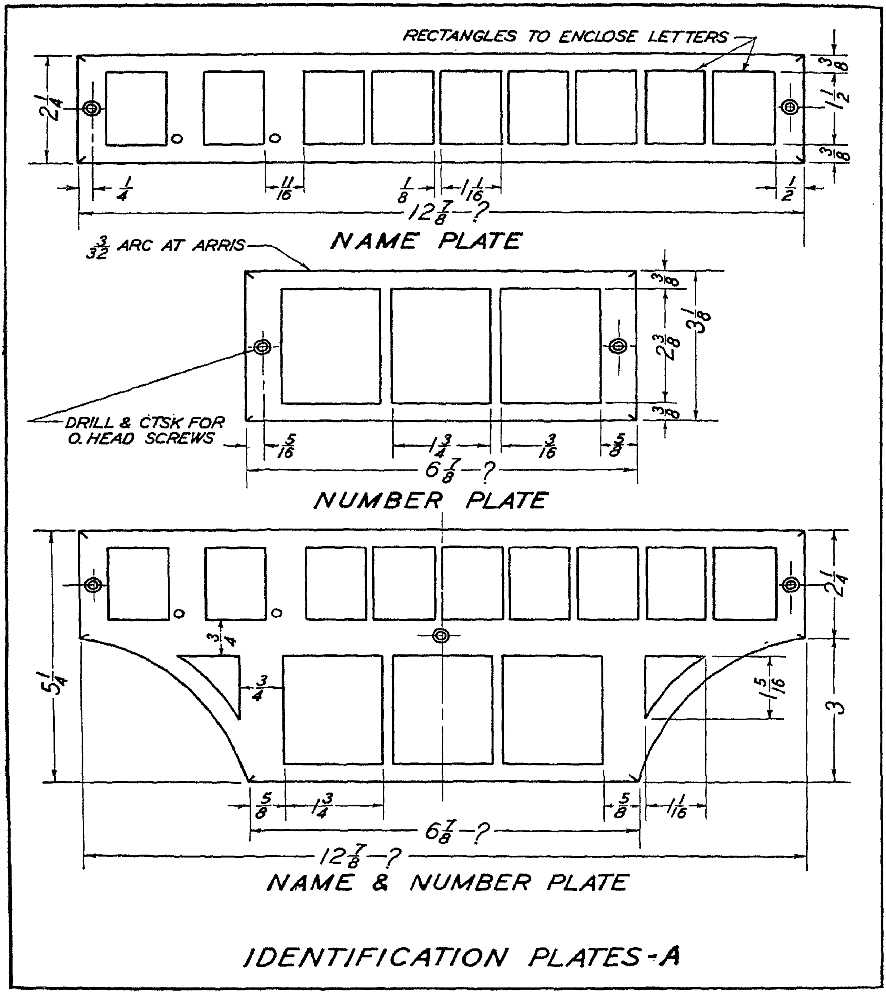

RECTANGLES TO ENCLOSE LETTERS
NAME PLATE
3/32 ARC AT ARRIS
DRILL & CTSK FOR O. HEAD SCREWS
NUMBER PLATE
NAME & NUMBER PLATE
IDENTIFICATION PLATES-A

Plate 10

Plate No. 10

IDENTIFICATION PLATES—A

Many name plates and house numbers of the type commonly used are not legible from the street. Plates of cast resinoids have a definite advantage over the older plates. In most cases, the distance to which a name or number is legible is doubled. In addition, a plastics plate lends a distinctive appearance. This is especially true when used on office doors and desks. Many types of these plates are being molded commercially where quantities are sufficient to warrant this type of production.

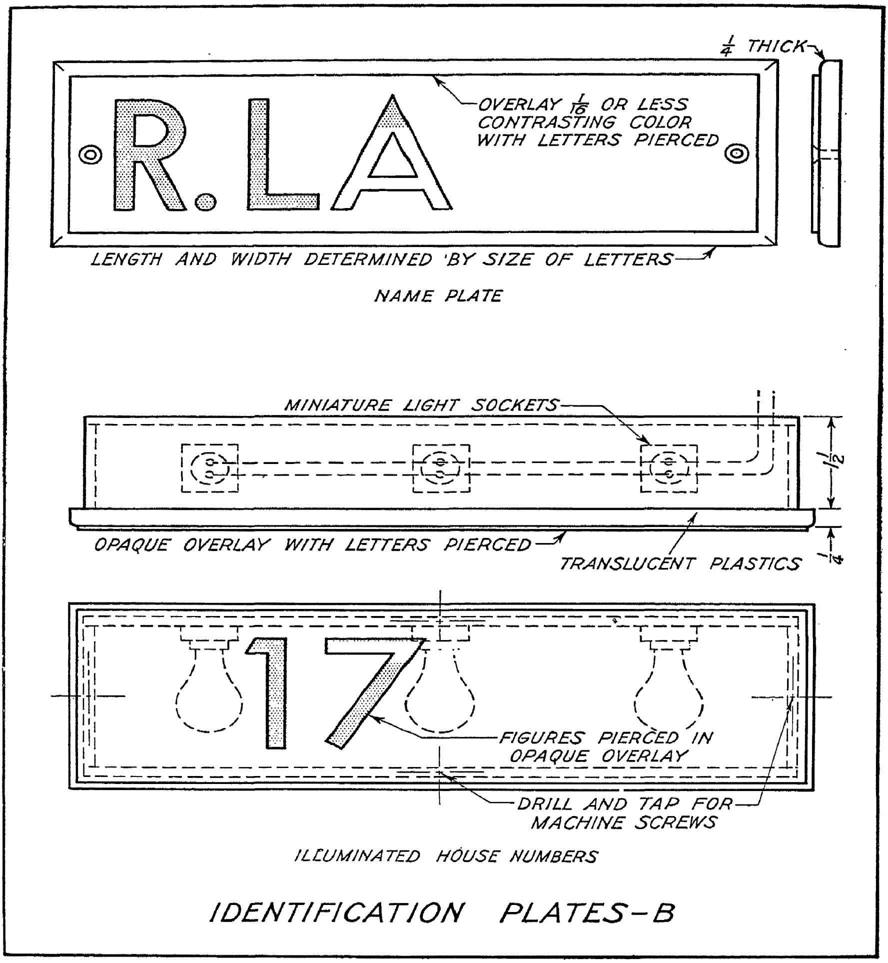
The *name plate* will vary in size as the material to be placed thereon varies. This may be said of all identification plates. For house name plates, letters 1½″ in height are practical and should be made from contrasting colors. Regular plastics cement may be used, with satisfactory results, for plates exposed to the weather. A slight discoloration takes place when exposed to the weather but most of it can be removed by cleaning.

Number plates should be larger than name plates since they are usually read at greater distances. Numbers 2⅜″ in height are suggested. They should not be placed too close together. A wider spacing of the numbers will increase the distance at which they are legible.

The *name* and *number plate* is a combination of the foregoing plates. The size and shape of the base will depend upon the number of characters to be used. If this design is not appropriate, it should be modified.

When an identification plate is mounted on a wood surface, holes should be provided for oval-head wood screws. Oval-head machine screws are suitable for mounting on metal. When used on a desk, bases similar to those used for cards may be made from plastics.

A plate of unusual design may be made by cutting out the letters on the base and cementing in letters cut from plastics of another hue. The front is surfaced and a thin sheet of clear plastics cemented on the entire area.



1/4 THICK
OVERLAY 1/16 OR LESS
CONTRASTING COLOR
WITH LETTERS PIERCED
R.LA
LENGTH AND WIDTH DETERMINED BY SIZE OF LETTERS
NAME PLATE
MINIATURE LIGHT SOCKETS
1 1/2
OPAQUE OVERLAY WITH LETTERS PIERCED
TRANSLUCENT PLASTICS
1/4
17
FIGURES PIERCED IN
OPAQUE OVERLAY
DRILL AND TAP FOR
MACHINE SCREWS
ILLUMINATED HOUSE NUMBERS
IDENTIFICATION PLATES-B

Plate 11

Plate No. 11

IDENTIFICATION PLATES—B

Identification plates, as illustrated in Plate 11, present two types: one providing for illumination and the other without. In either case, the size of the plate will be determined by the number of characters and the use for which the plate is being planned.

The *name plate* is constructed from $\frac{1}{4}''$ sheet stock and a thin overlay. The letters or figures should be laid off accurately on the overlay before it is cemented in place. Before the cement sets, a sharp knife should be used to cut and remove the outlines. If the overlay is $\frac{1}{16}''$ or more in thickness, the letters should be pierced before mounting. Excess cement should be removed carefully with a solvent. Arrises on the front corners should be slightly rounded with a file and abrasive papers. For mounting on wood, oval-head, non-rusting screws are best. If the mounting is on metal the holes should be prepared in the same manner as for wood screws. If a buffing wheel is used for finishing operations, care should be taken in buffing the letters so that thin sections will not cut through.

Illuminated *house numbers* offer an opportunity for individual design, both in construction and in the colors of plastics used, to produce the proper light effect. A box $1\frac{1}{2}''$ deep, and wide enough to illuminate the letters or figures used, should be constructed of plastics or other insulating material. Miniature light sockets should be wired in parallel and connected to a convenient light switch. A $\frac{1}{4}''$ cover of translucent plastics of the color desired is made for the box and held in place with oval-head machine screws as indicated. Holes must be drilled and tapped for machine screws (see Table VI). The overlay may be applied the same as for the name plate just described, except that an *opaque* plastics must be used to shut off all light but that which passes through the pierced characters. This type of box may be anchored to the wall or inserted flush with the surface. In either case, if the front is exposed to the weather, a thin cork or rubber gasket should be placed underneath the edges of the cover plate to keep out moisture.

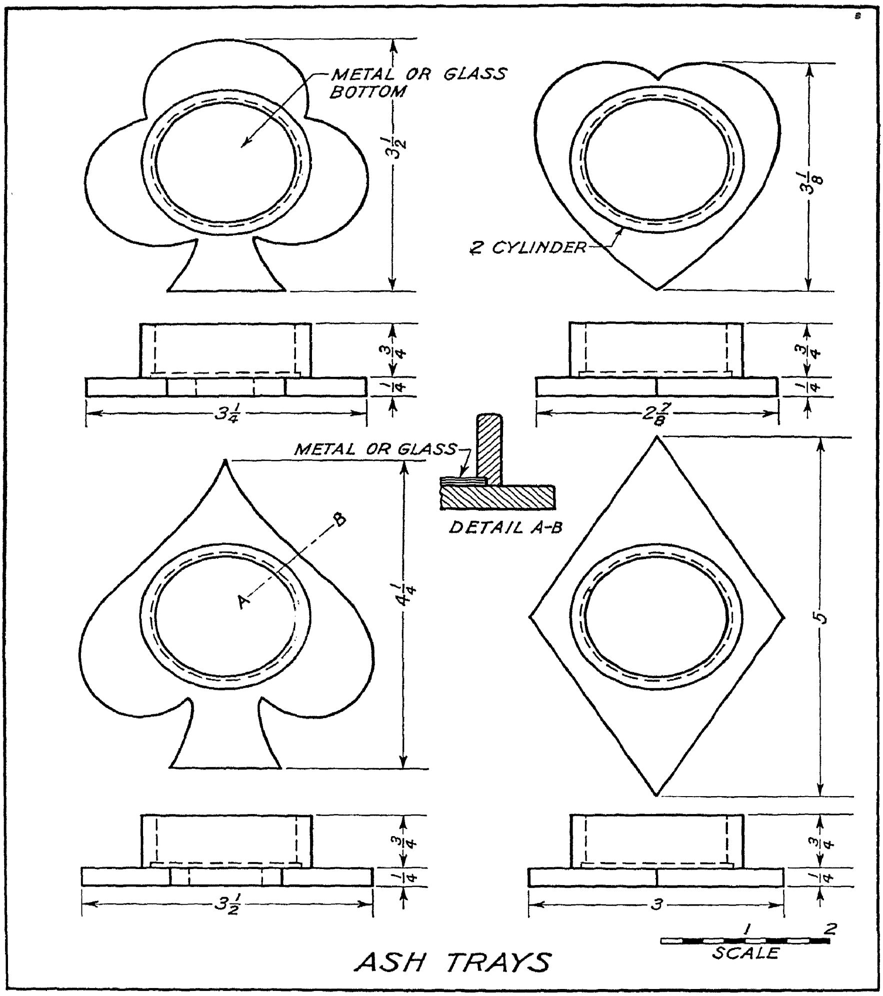

METAL OR GLASS BOTTOM
$3\frac{1}{2}$
$3\frac{1}{8}$
2 CYLINDER
$\frac{3}{4}$
$\frac{1}{4}$
$3\frac{1}{4}$
$2\frac{7}{8}$
METAL OR GLASS
DETAIL A-B
B
A
$4\frac{1}{4}$
5
$3\frac{1}{2}$
3
1
2
SCALE
ASH TRAYS

Plate 12

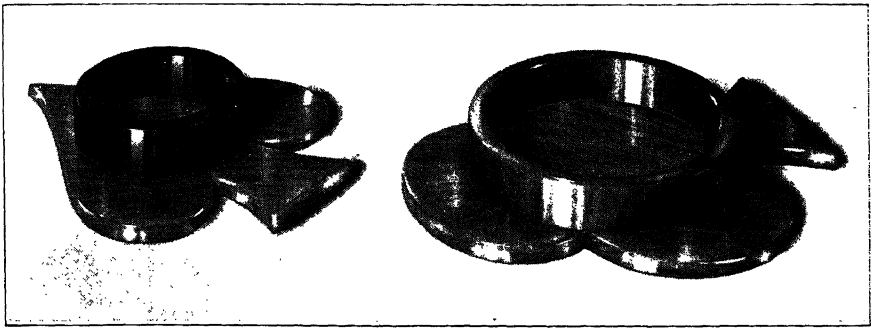


Figure 129. Ash trays.

Plate No. 12

ASH TRAYS

It is true that cast resinoids will char or discolor when subjected to a direct flame or to extreme heat. In most cases, however, the plastics surfaces possess enough heat resistance to make them practical for use in *ash trays*. If additional protection is necessary, a glass or metal plate may be inserted in the tray ring (see *detail A—B*).

Cast resinoids may be obtained in colorful sheets and rings which can be combined to fabricate an attractive set of ash trays. Color combinations of interest to the individual can be selected.

Rings are cut from a cylinder of the proper size. The bottom edge of the ring should be perfectly flat for cementing. Small dowels should be used in the base and ring to hold the ring in place while cement is setting. Polishing operations should be performed on both parts before the ring is cemented. Buffing can be done after the cement has set.

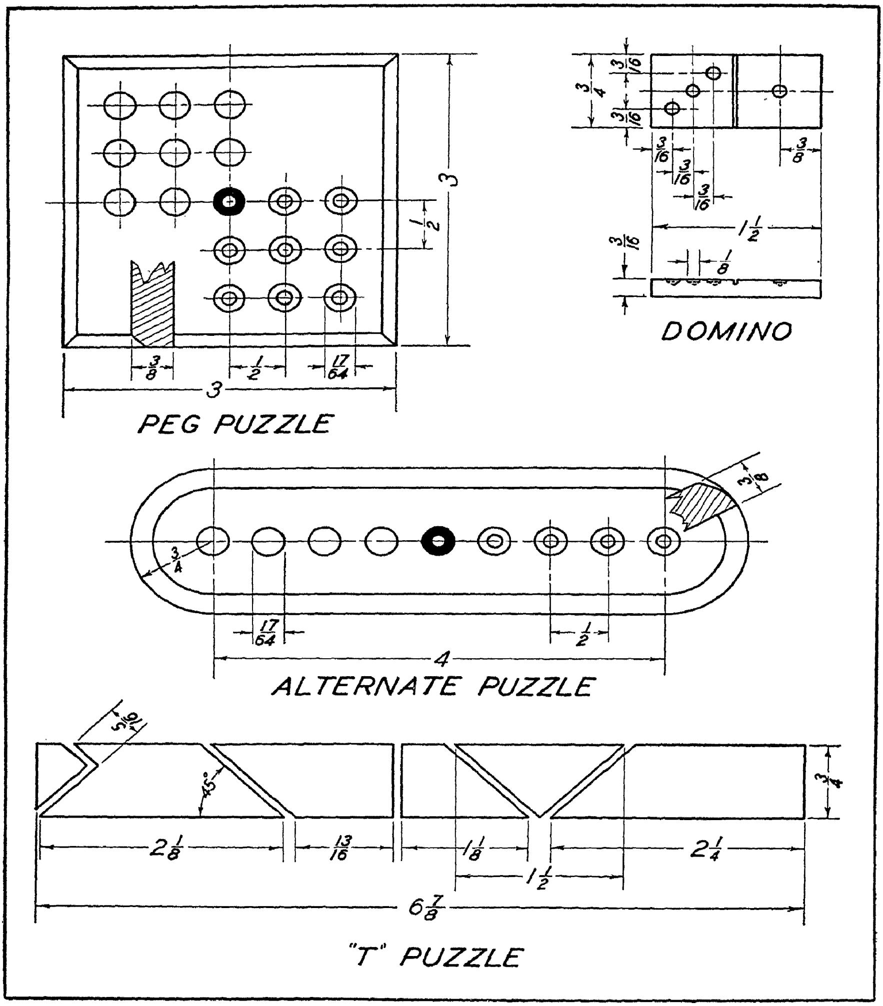


Plate 13

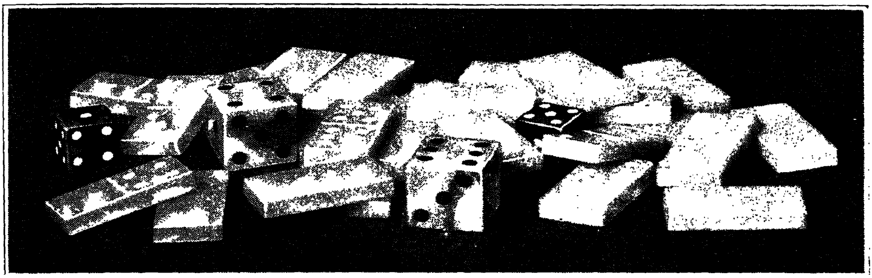


Figure 130. Dominoes and Dice.

Plate No. 13

GAMES AND PUZZLES

Peg Puzzle.—The object of the game is to shift the pegs so that those of one color occupy the position of another color. Pegs are not removed from the board but are moved, one at a time, from one hole to the next following the center lines. A player may jump over a peg if the next hole is empty, but the peg jumped is not removed. Plate 13 shows the hole size necessary for pegs cut from $\frac{1}{4}''$ plastics rod. Pegs are $\frac{9}{16}''$ long. Eight pegs each, of two different colors, are required.

Dominoes.—Pieces are cut into rectangles, laid out, and buffed before the holes are drilled. The division line is made by a saw kerf. Holes for the dots are drilled just deep enough so that the lips of a drill drop below the top face. Holes and division lines may be made to stand out either by wiping-in lacquer or by filling them with plastics cement. There are twenty-eight dominoes in a double-six set.

Alternate Puzzle.—The object of the game is to shift the position of the group of pegs so that they are reversed. One peg is moved at a time. It may jump another, but it cannot move backwards. Four pegs each, of two different colors, are necessary.

"T" Puzzle.—As the name implies, the pieces are to be arranged in the shape of a letter "T." This is made from $\frac{1}{8}''$ stock. A strip $6\frac{7}{8}''$ should be squared-up first. The five pieces to the right, in the illustration, are cut to the dimensions shown. The small piece at the left is discarded.

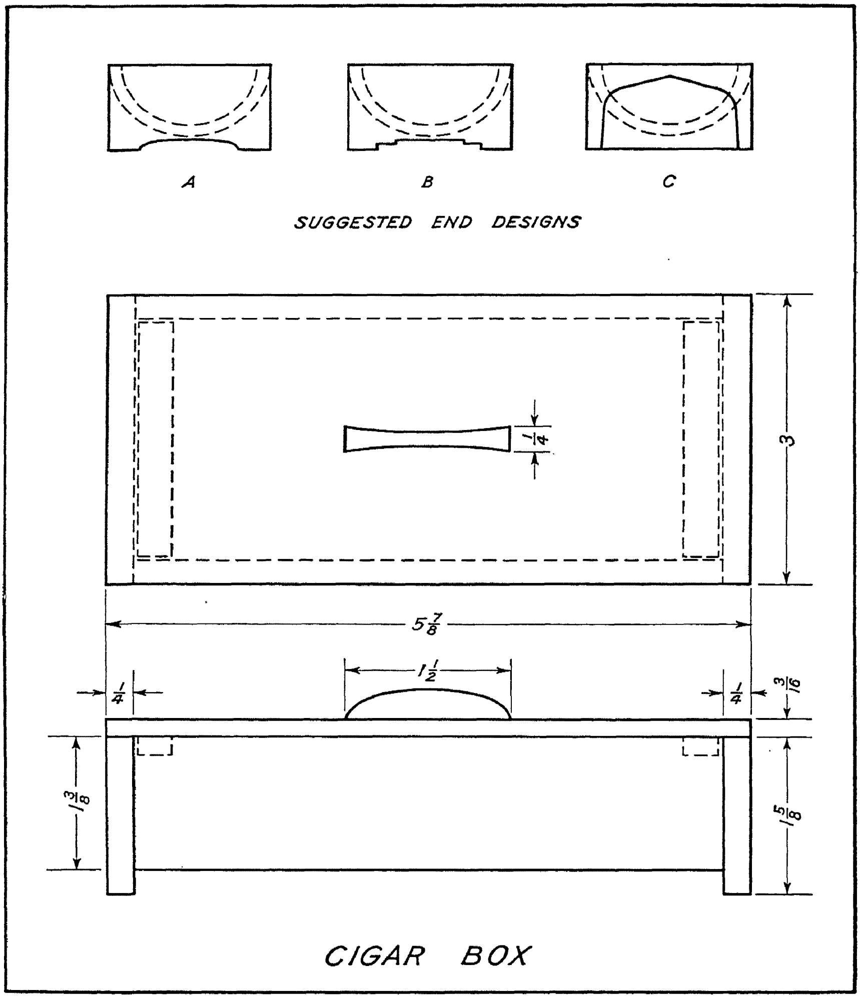

A
B
C
SUGGESTED END DESIGNS
1/4
3
5 7/8
1 1/2
1/4
1/4
3/16
1 3/8
1 5/8
CIGAR BOX

Plate 14

Plate No. 14

CIGAR BOX

The *cigar box* body is made from one-half of a 3″ cylinder section. Stock $\frac{1}{4}'' \times 1\frac{5}{8}'' \times 3''$ is used for ends. Small dowel pins should be used to keep the ends from slipping while clamps are applied. These dowels may be made from small finishing nails cut and placed in small holes drilled in the ends of the half-cylinder. Holes to match them are drilled on the inside of the ends. Care must be taken not to drill through to the outside.

The lid is constructed of $\frac{3}{16}''$ material with a small strip of plastics cemented near the ends to hold the lid in place. These strips must fit inside the half-cylinder at the ends as indicated on the drawing.

A small handle is shaped from $\frac{1}{4}''$ plastics and fastened to the lid from underneath with drive screws or better with self-tapping screws. It will be noted on the top view that the sides of this handle are concave, and in the front view it is elliptical.

End design *A* is simple to construct but will be found to match the handle just suggested. A check should be made before cutting the elliptical shape in the end to not overlap the section of cylinder on the inside.

In design *B*, the offsets are in the from of steps. The steps are balanced on either side but the size of each step is different. Dowel pins and cement should be used to fasten the ends as has been explained.

Design *C* offers an overlay suggestion requiring thin-sheet plastics. Cellulose acetate plastics .015″ to .030″ in thickness will make a very satisfactory overlay. This may be cut out and the edges smoothed before it is cemented in place. When an overlay is used, drive screws, machine screws, or self-tapping screws may be used to assemble the ends if the heads are countersunk. If, however, the overlay is of transparent or translucent plastics, metal dowel pins should be used.

The box illustrated here can be made larger by using a cylinder with larger diameter and increasing the ends accordingly.

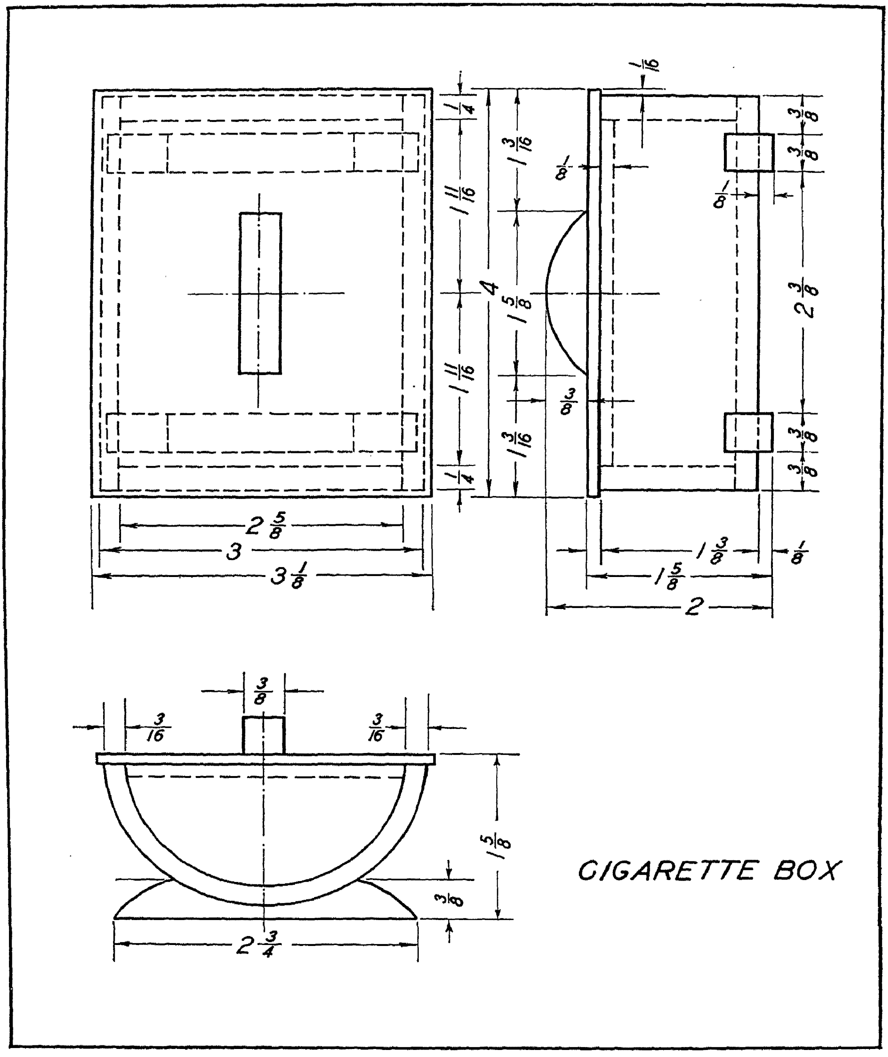


Plate 15

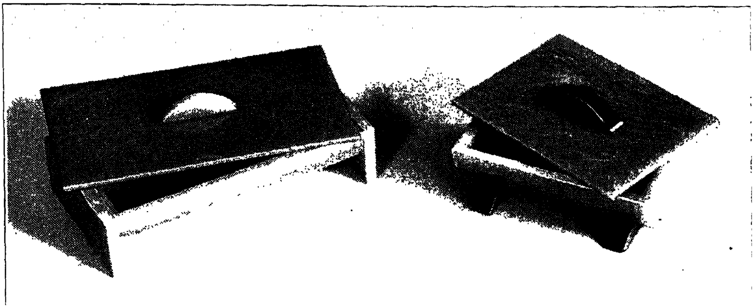


Figure 131. Cigar box and cigarette box.

Plate No. 15

CIGARETTE BOX

A *cigarette box* of the design shown in Plate 15 requires one-half of a 3″ cylinder section. Ends are cut from $\frac{1}{4}$″ sheet plastics and carefully fitted to the cylinder walls before the cement is applied. Two feet are shaped from $\frac{3}{8}$″ stock and all finishing operations are completed before assembling is begun. Two pieces of $\frac{1}{8}$″ stock are cemented together to form the cover. The lower section of the cover is fitted to the inside of the box to hold the cover in its proper place. Stock $\frac{3}{8}$″$\times\frac{3}{8}$″ is used for the handle and this, too, should be finished before assembling.

A drive screw or machine screw should be used to reenforce the handle from underneath the cover. Cement should be used to keep it from turning. Short metal dowels, carefully fitted will hold the feet in place while the cement sets.

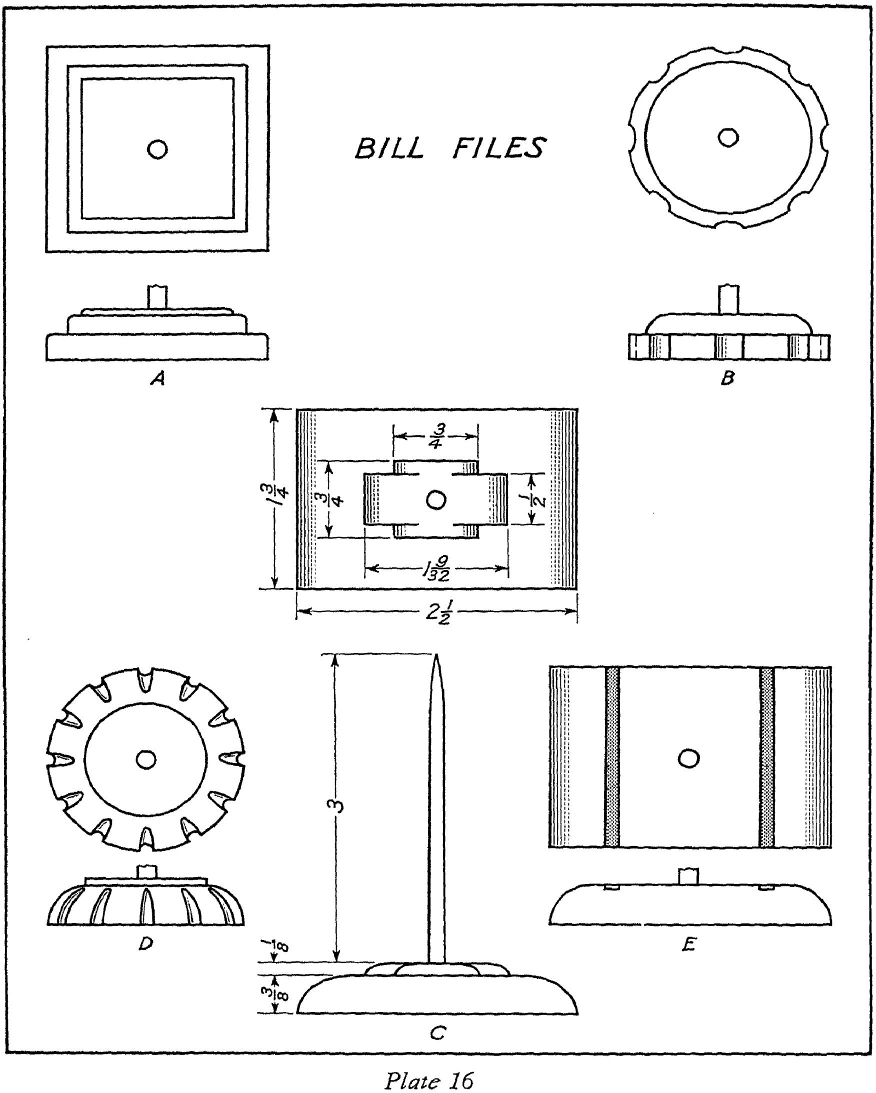


Plate 16

Plate No. 16

BILL FILES

Bill files offer an opportunity for individual design as may be seen on Plate 16. This problem may be designed to match other pieces of desk equipment or it may be designed for use elsewhere. Several suggestions are shown, but only one bill file is dimensioned to give a general idea of size.

Design *A* is laminated and uses three pieces of varying thickness for the base. Arrises on the top of each piece are slightly rounded. Rods $\frac{1}{8}''$ to $\frac{3}{16}''$ in diameter may be used for posts. Aluminum, stainless steel, and brass are suitable. If brass is used, it sould be given a coat of lacquer after it has been polished.

Sketch *B* introduces *flutes* which can be made with an ordinary round file. Care should be taken to get all flutes evenly spaced. All buffing and polishing should be done before the center hole for the post is drilled and tapped.

The base of *C* is made of $\frac{3}{8}''$ plastics with an overlay of $\frac{1}{8}''$ material. This problem requires special care in handling a file to shape some of the elliptical curves. Practically all dimensions are given on the plate so the results will depend largely upon the neatness and accuracy of the worker.

Base *D* should be properly shaped before the small flutes are added. If power buffing and finishing is used, care should be taken not to destroy the effect of neatly shaped flutes. A small disc is added to the top, and held in place by the post.

Design *E* suggests either an inlay or an overlay. A dado for the inlay may be cut by using a miter box or it may be filed to the proper size. Inlays should be in place before finishing operations are started. If an overlay is to be used, thin strips of cellulose acetate should be cemented on at the proper places. When the cement has dried sufficiently, polishing operations should be completed.

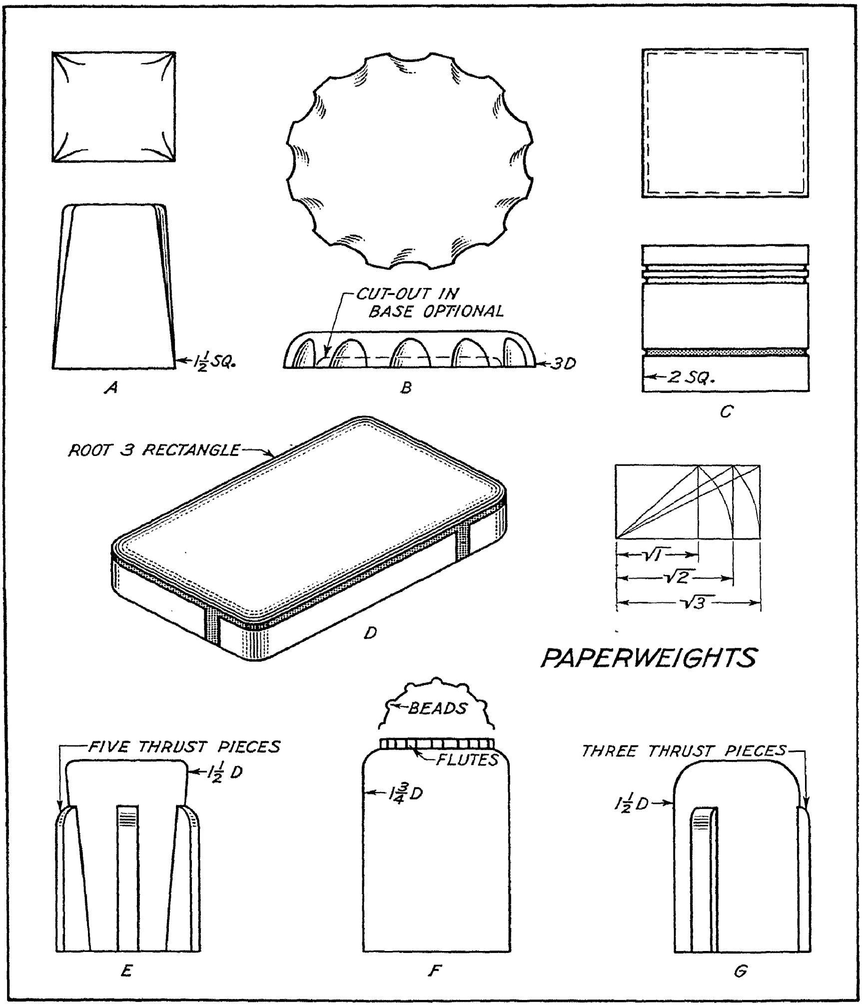

1½ SQ.
A
CUT-OUT IN
BASE OPTIONAL
3D
B
2 SQ.
C
ROOT 3 RECTANGLE
D
√1
√2
√3
PAPERWEIGHTS
FIVE THRUST PIECES
1½ D
E
BEADS
FLUTES
1¾ D
F
THREE THRUST PIECES
1½ D
G

Plate 17

Plate No. 17

PAPER WEIGHTS

A *paper weight,* if attractively made, is a useful and desirable article to have on any desk. Since weight is the principal factor and the function of all paper weights is the same, more attention should be given to beauty and design. Most of the suggested designs on Plate 17 are simple, with little or no decoration added; therefore, the value will depend largely on the *design* and *finish* of the problem.

A is formed from 1½″ square stock and is approximately 2¼″ in height. The arrises of the frustum are camfered from a point near the bottom gradually increasing toward the top as shown. Jet black or water clear, cast resinoid will make an attractive weight.

B is ½″ thick and 3″ in diameter. The top arris is removed and flutes are cut with a file. To make this model more attractive, translucent plastics may be used with a routed base portion. The cut-out is designed for inserting a photograph or monogram.

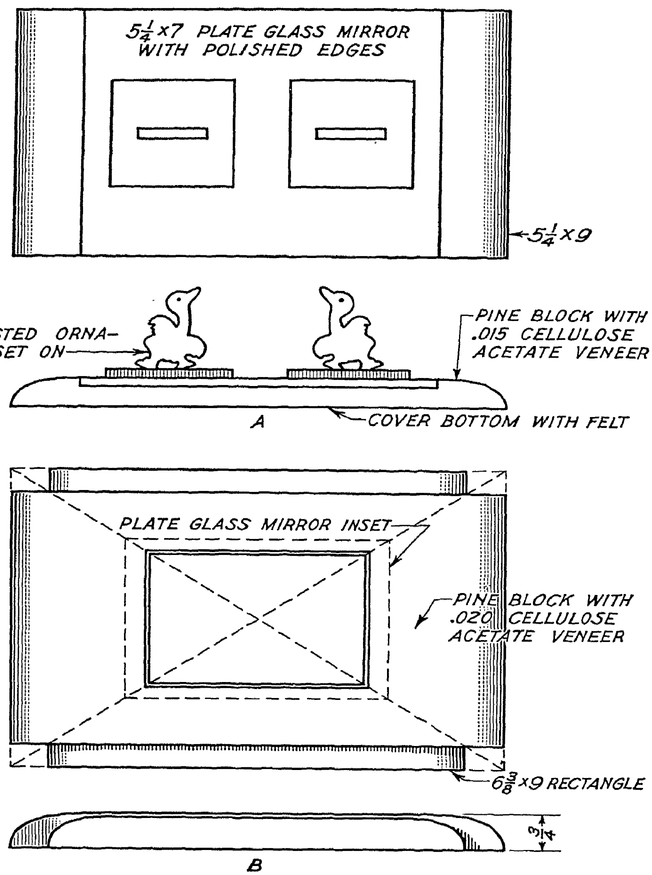
C is 2″ square and has three bands of inlay running horizontally around the block. Unequal spacing should be provided by these bands as shown on the drawing (see Chapter 7).

D is a root rectangle as shown in the smaller diagram to the right. Plastics, not less than ½″ in thickness, should be used in order to provide sufficient weight. A carefully planned overlay design will add to its beauty.

E should be made from a section of 1½″ diameter rod and tapered toward the base. This should not be attempted unless a lathe is available. Five thrust pieces are cut and fitted to the tapered surface. Finishing and polishing operations should be completed before parts are assembled.

F will require the rounding-off of the arris at the top of the column. The circular piece on top may be made from a beaded or fluted section cut from a special casting or it may be laid off on sheet plastics and formed by hand. Files and a jeweler's saw make up the necessary tool equipment.

G begins with a section of 1½″ rod, rounded as in *F*. Three thrust pieces of contrasting color are fitted and cemented in place.



CENTERPIECES

Plate 18

Plate No. 18

CENTERPIECES

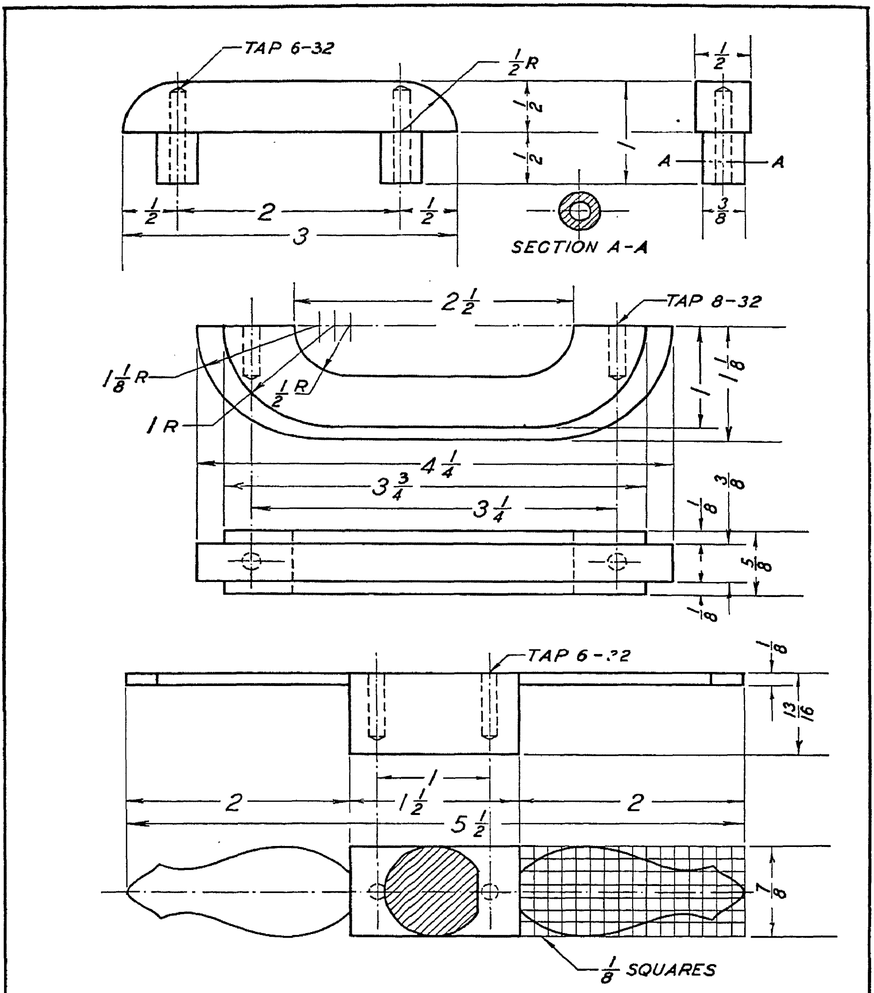
Centerpieces involving the use of plastics, wood, and glass are suggested on Plate 18. Before starting to build either of these centerpieces, a check on the necessary material and equipment to be used should be made.

Centerpiece *A* starts with a pine block $\frac{3}{4}'' \times 5\frac{1}{4}'' \times 9''$. A section in the center of the top $5\frac{1}{4}'' \times 7''$ is routed out for a plate-glass mirror of the same size. The one-inch section remaining on either end is shaped to resemble a one-quarter ellipse. This surface should be smoothed and sanded since any defects will be noticeable through the veneer. Cellulose acetate .015″ in thickness and of the desired color should be carefully cemented on the front and back edges. After the cement has set, a sharp knife should be used to trim the edges and a fine-cut file used to finish off the job. Sheets of the same thickness should be cut a little larger than the area of the ends and cemented to the curved surfaces. All edges should be carefully smoothed off after the cement has set. The base is now ready for the mirror.

A mirror of the proper size may be purchased from a plating shop or the plate glass may be cut in the laboratory and the edges polished by hand before it is sent to a plating company.

Sections cut from special castings may be mounted on small plastics blocks and used for decoration. Translucent figures are usually more attractive than the opaque. The worker, however, should plan the color or colors to be used. Felt should be used to cover the entire bottom.

Centerpiece *B* is similar in construction to the above except that the mirror is set in a routed portion and held in place by the acetate veneer placed over both wood and glass. Chamfered edges are made around the mirror opening on the top surface. A slightly heavier (.020″) veneer of cellulose acetate may be used since the entire surface is to be covered. The same procedure should follow in finishing this problem as for *A*. As shown on Plate 18, all corners of the exposed part of the mirror should terminate on the diagonal.



DRAWER PULLS

Plate 19

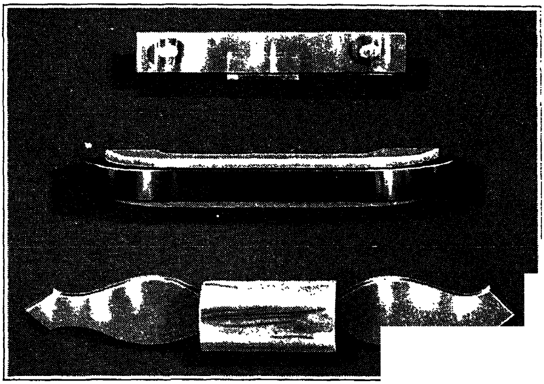


Figure 132. Drawer pulls.

Plate No. 19

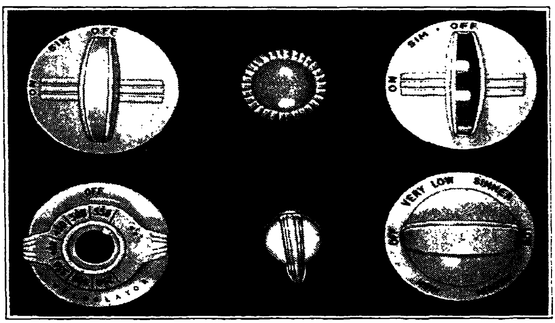
DRAWER PULLS

Three designs for *drawer pulls* are suggested in Plate 19. These are for the most part self-explanatory. They are further illustrated in Figure 132. Figure 133 illustrates a commercial type of pull of molded plastics.

The drawer pull at the top of the plate is made from $\frac{1}{2}''$ square stock. The size should be determined by the area on which it is to be placed.

The center pull is a laminated problem. Care should be taken to properly shape and surface the edges of both upper and lower pieces before cementing them together.

The drawer pull at the bottom of the plate is designed to be made in pairs for a large drawer front. Wings at either end are fastened to a wooden drawer front, either with cement or with drive screws. All pulls illustrated are drilled and tapped for machine screws.



(Courtesy of Consolidated Molded Products, Inc.)

Figure 133. Molded stove knobs.

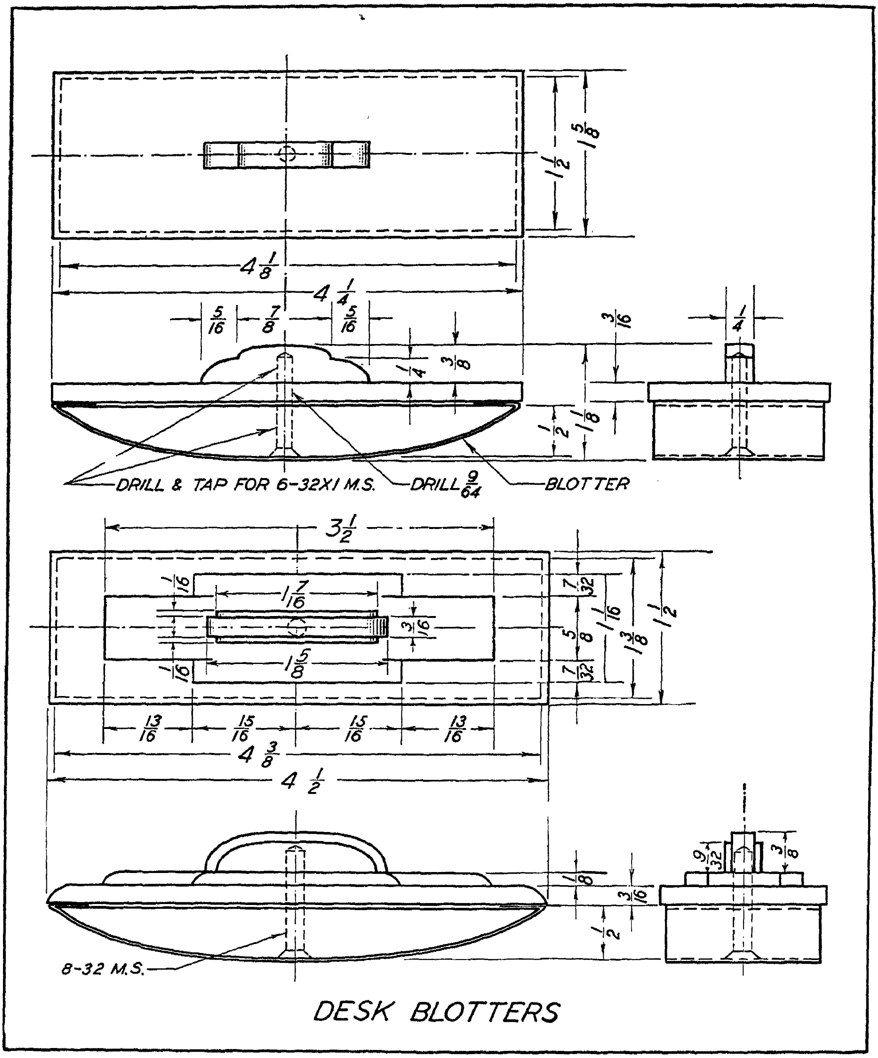

DRILL & TAP FOR 6-32X1 M.S.
DRILL 9/64
BLOTTER
8-32 M.S.
DESK BLOTTERS

Plate 20

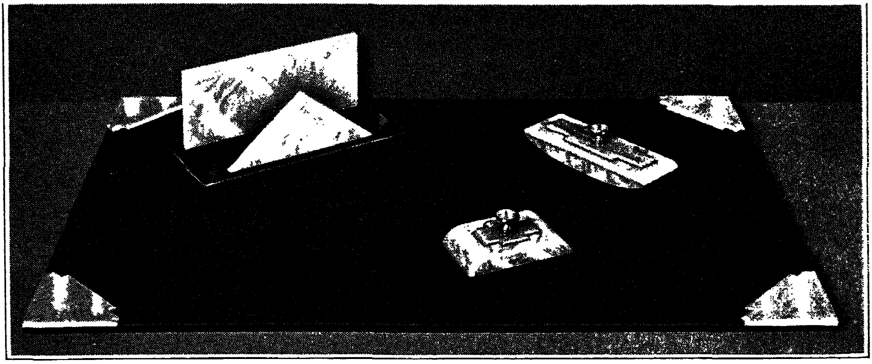


Figure 134. Blotter pad corners, letter holder, desk blotter, and paper weight.

Plate No. 20

DESK BLOTTERS

The *desk blotters* illustrated on Plate 20 may be made to match other pieces of desk equipment or may be used as single units. By careful selection of colors and through the use of trim, harmonizing effects may be worked out (see Chapter 7). The simple method by which they are assembled makes it easy for any one to renew the blotters. By turning the knob to the left, the blotter is released and a new one of the proper size can be inserted in its place. If an overlay is used, the same machine screw assembly will hold it in place without the use of cement.

For the bases, pieces of $\frac{1}{2}''$ stock are cut and laid off with the aid of a templet. Since the front and back must be uniform, they should be accurately scribed on both sides. It will be noted that the bases and knobs are drilled and tapped for machine screws while the overlay and the projecting tops are drilled for clearance. Square stock is used for the knob on the lower design and can be fashioned entirely by hand, using files and abrasive papers.

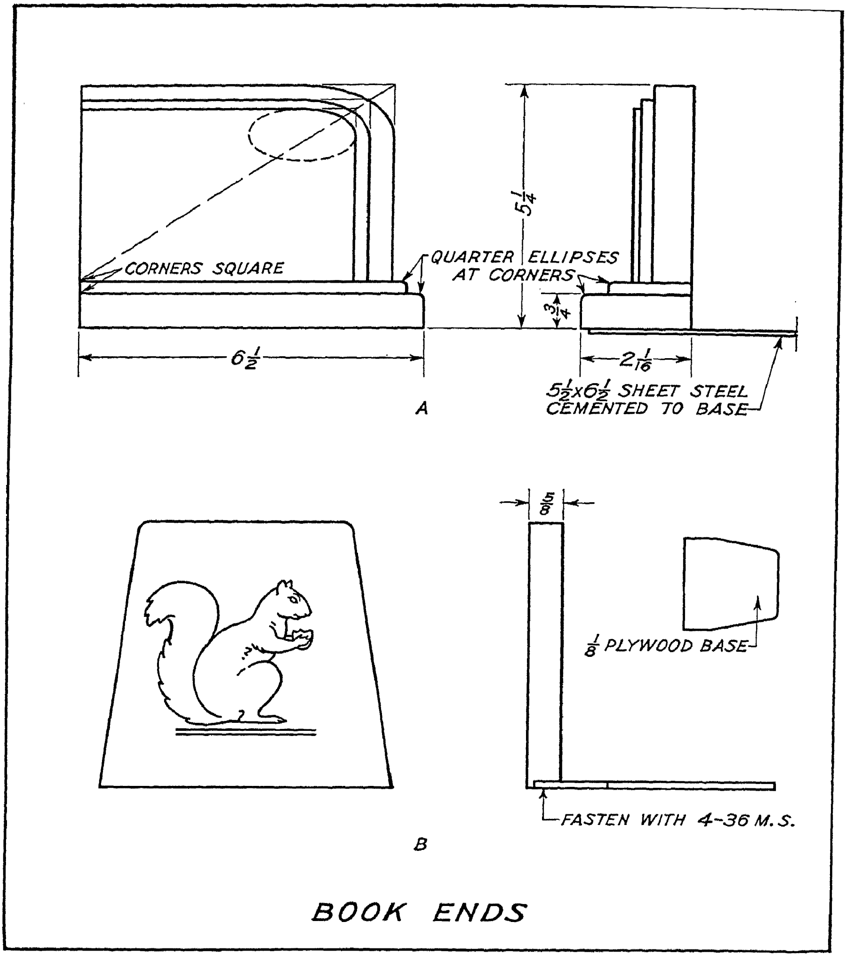

CORNERS SQUARE
QUARTER ELLIPSES AT CORNERS
5 1/4
3/4
6 1/2
2 1/16
5 1/2 x 6 1/2 SHEET STEEL CEMENTED TO BASE
A
5/8
1/8 PLYWOOD BASE
FASTEN WITH 4-36 M.S.
B
BOOK ENDS

Plate 21

Plate No. 21

BOOK ENDS

Book ends may be built up by using plastics sheets of various thickness or they may be fashioned from one piece and the enrichment applied upon it.

A few general dimensions are given on design *A*, Plate 21. The base should be made from $\frac{3}{4}''$ stock to add weight. On top of this, a $\frac{1}{4}''$ piece is located according to the diagonal spacing shown on the front view. Three pieces are cemented together to form the face of the book end. The length and height of the overlays are determined by the diagonal as shown, thus making the margins on the end wider than those on the top. The base and top should be assembled with machine screws of the proper size. Heads of these screws should be countersunk and if they are used to hold the sheet metal to the bottom the holes should be countersunk just enough to be below the surface of the metal. Adhesive cement may be used to hold the metal base to the plastics. All scratches should be removed from the large areas before buffing and polishing operations are attempted.

Another type of book end is suggested in design *B*, which is made of one piece of $\frac{5}{8}''$ plastics and a base of $\frac{1}{8}''$ plywood. The plain surface on the end offers to the more artistic group and to those wishing to explore the art of carving, a chance to express themselves. When a particular design is planned, it should be laid off on thin paper and then cemented to the plastics with a rubber cement. Hand-carving tools may be used successfully if the plastics is occasionally dipped in warm water, which tends to soften the plastics and permit smoother cuts. If a rotary tool is available, carving burrs may be used and more intricate designs accomplished. The ends should be rabbeted for a $\frac{1}{8}''$ plywood base which is held in place as indicated. Bases made either of metal or of wood should be covered with felt to prevent marred furniture.

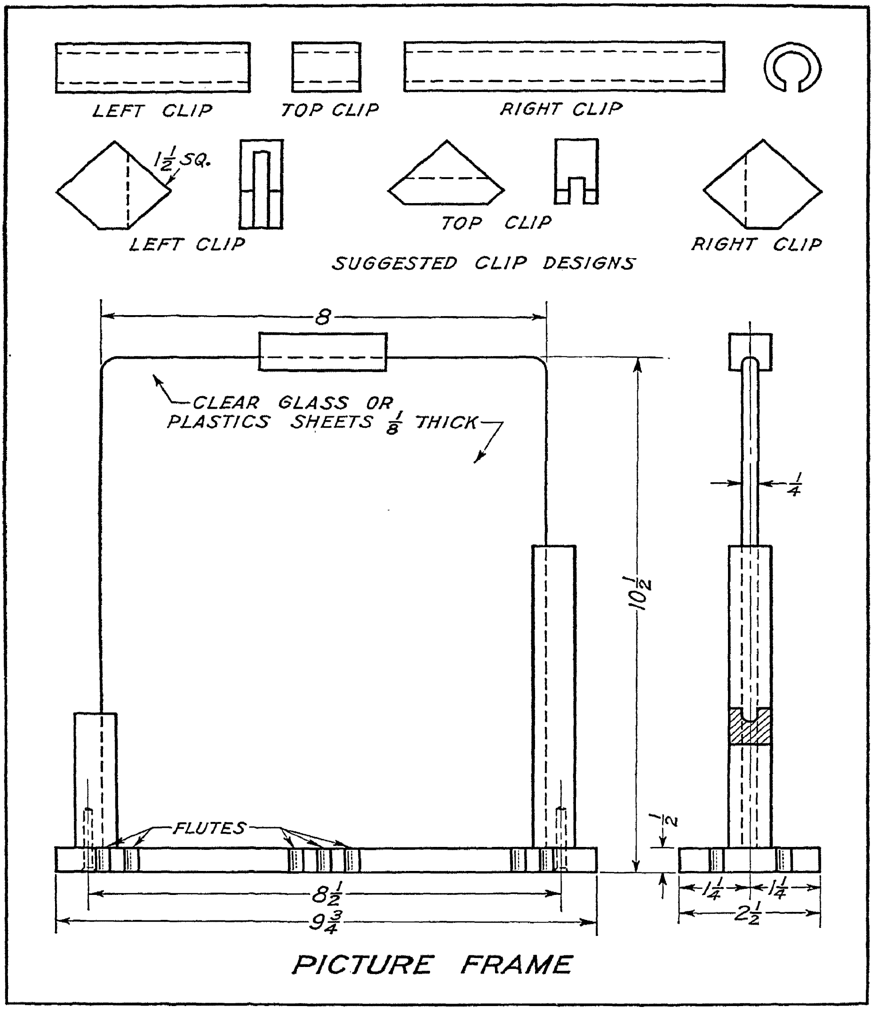

LEFT CLIP
TOP CLIP
RIGHT CLIP
$1\frac{1}{2}$ SQ.
LEFT CLIP
TOP CLIP
RIGHT CLIP
SUGGESTED CLIP DESIGNS
8
CLEAR GLASS OR PLASTICS SHEETS $\frac{1}{8}$ THICK
$\frac{1}{4}$
$10\frac{1}{2}$
$\frac{1}{2}$
FLUTES
$8\frac{1}{2}$
$9\frac{3}{4}$
$1\frac{1}{4}$
$1\frac{1}{4}$
$2\frac{1}{2}$
PICTURE FRAME

Plate 22

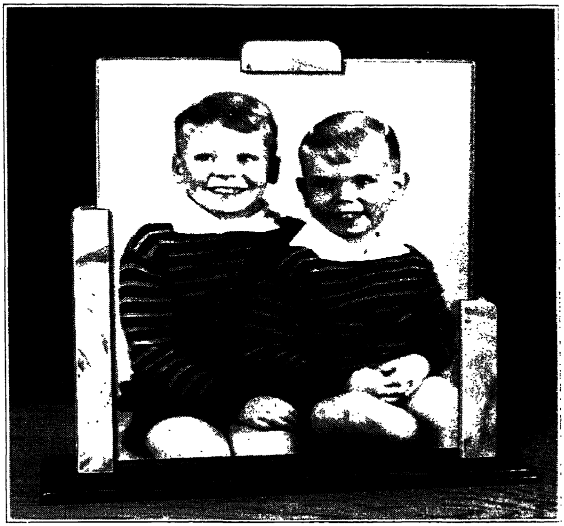


Figure 135. Picture frame.

Plate No. 22

PICTURE FRAME

The *picture frame* illustrated is characterized by simplicity and beauty. It is sturdy and well balanced so long as the proper proportions are maintained. These qualities will be determined by the size of the picture.

The plates may be made from plastics, but glass will be found more economical and easier to obtain. For the smaller sizes, single strength glass is recommended. The plates should be cut to size and the edges hand-dressed with either a silicon carbide or aluminum oxide stone. After the edges are reduced to a true surface a small chamfer on all arrises made with a fine grit stone will improve their appearance.

After the plates are fitted to the photograph, three clamps are made, with a friction fit, from plastics rods to hold the plates tight against the photograph. These clamps are made from $\frac{3}{4}''$ square rods and the grooves carefully cut to size. Care should be taken to keep all abrasives used away from the surfaces of the plates, whether glass or plastics.

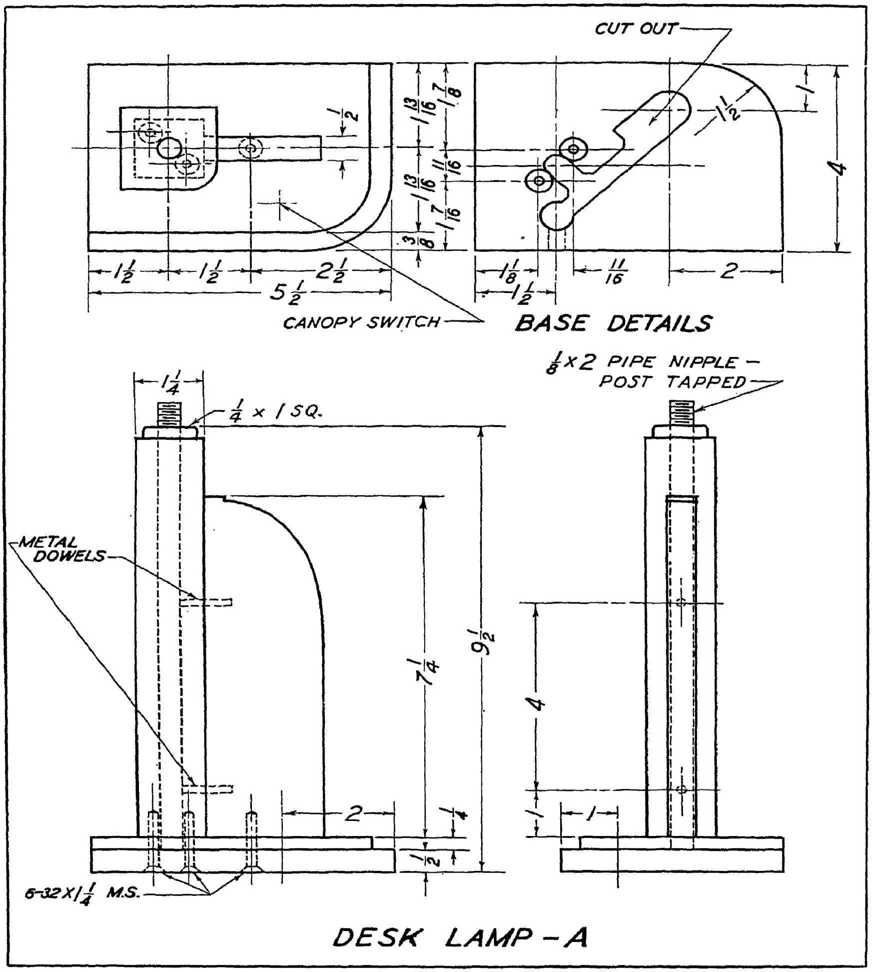
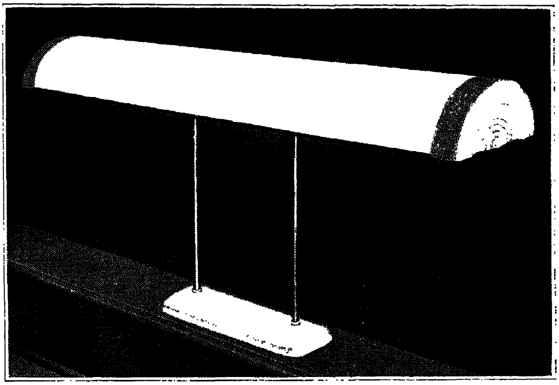

CUT OUT
BASE DETAILS
CANOPY SWITCH
METAL DOWELS
6-32 X 1 1/4 M.S.
1/4 x 1 SQ.
1/8 x 2 PIPE NIPPLE – POST TAPPED
DESK LAMP – A

Plate 23



(Courtesy of Monsanto Plastics)

Figure 136. Miller fluorescent light fixture of cellulose acetate.

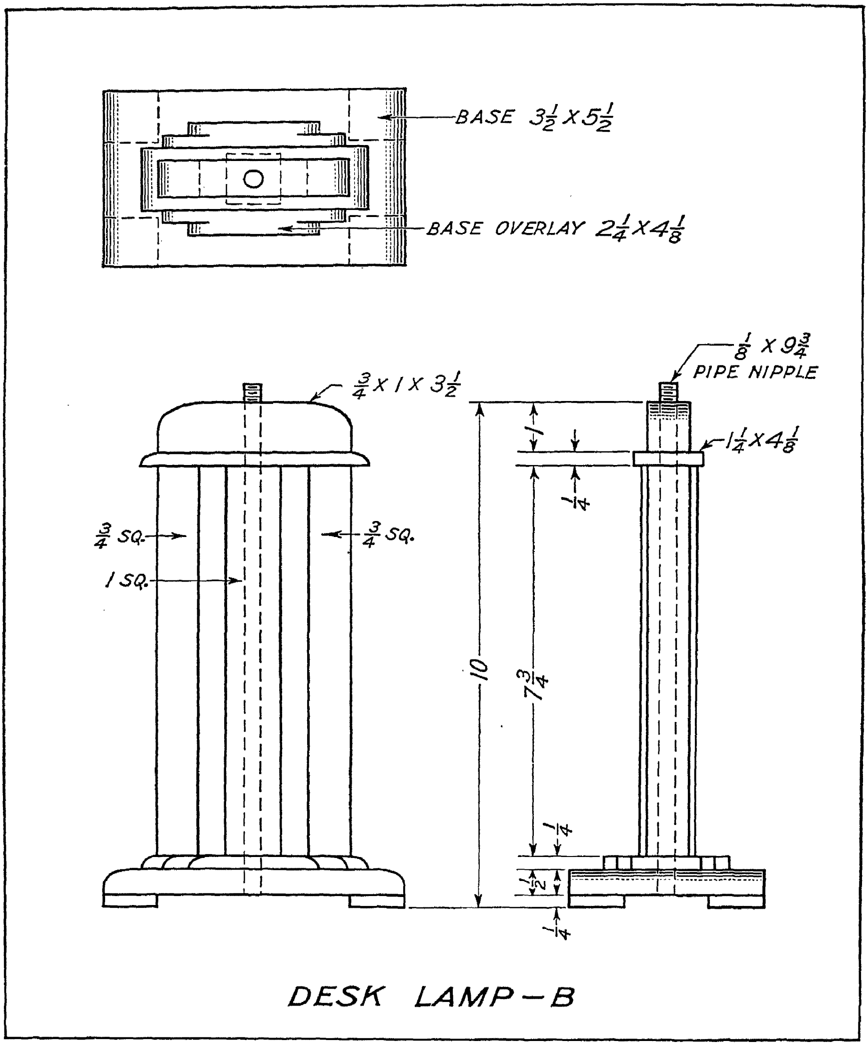
Plate No. 23

DESK LAMP—A

The *desk lamp* shown on Plate 24 is designed to match the book ends shown before. The main part of the base should be the starting point on the lamp. Cut it to shape and lay out all holes and cut-outs before the other pieces are made. Since the cut-out is covered, it may extend clear through the $\frac{1}{2}''$ piece.

A $\frac{5}{16}''$ hole is drilled the full length of the post. Special long drills or a wood-boring drill will have to be used on the central portion in order to obtain enough bit length. The post is tapped at the end for a $\frac{1}{8}''$ pipe nipple on which is mounted a light socket. Place at least one metal dowel between the cap and post so that the cap will not turn on the post.

Only one cemented joint is necessary for purposes of construction. The post brace is cemented to the post and reenforced with metal dowels. If desired, thin sheets of cellulose acetate plastics may be cut and cemented on the sides of this brace, leaving an appropriate margin on the elliptical side. The light is controlled by means of a canopy switch located in the cut-out of the base. Space unoccupied by the switch will be found very essential to conceal the necessary wiring.



BASE 3½ X 5½
BASE OVERLAY 2¼ X 4⅛
⅛ X 9¾ PIPE NIPPLE
¾ X 1 X 3½
1¼ X 4⅛
1
¼
¾ SQ.
¾ SQ.
1 SQ.
10
7¾
¼
½
¼
DESK LAMP—B

Plate 24

Plate No. 24

DESK LAMP—B

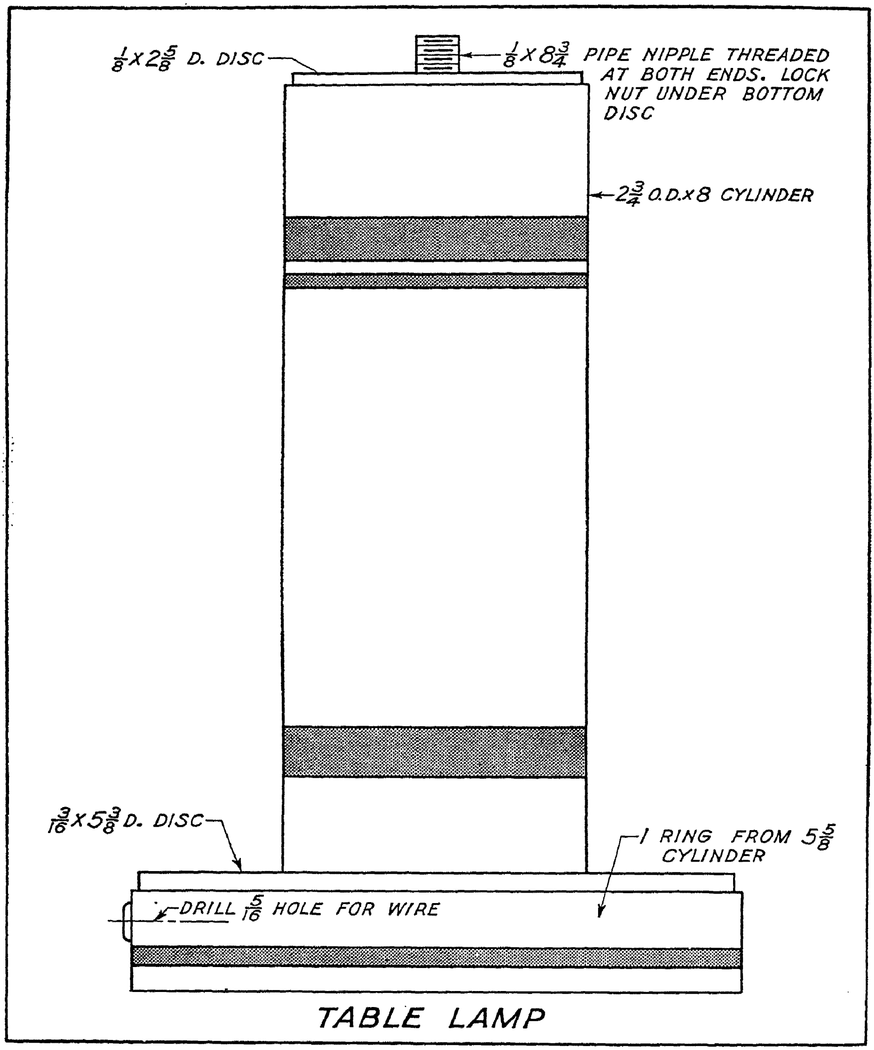
Desk Lamp B is designed primarily as a unit in a desk set. Overlay designs similar to the one shown here will be found on various other desk units. If several units are planned for a set, a color scheme should be worked out before any work is begun. A certain color may be used for overlay or trim on each of the units. In this manner, a number of pieces may be grouped with pleasing results.

The base of this lamp is formed from ½″ stock. One-quarter ellipse curves are made on the ends only. A center hole is drilled and tapped for a ⅛″ pipe nipple. Four blocks, ¼″ x 1″ x 1″, are cemented to the base for feet as shown. Another piece of plastics ¼″ x 2¼″ x 4⅛″ is carefully laid out and shaped for an overlay as indicated on the plate.

Three posts are cut, two from ¾″ square stock and one from 1″ square stock. A 13/32″ hole is drilled through the center of the one-inch square post. Extra long drills may be necessary to complete the job of drilling.

Two pieces are used to complete the top of this lamp. One piece, ¼″ x 1¼″ x 4⅛″, is shaped to match the base and a 13/32″ hole is drilled in the center. The other piece ¾″ x 1″ x 3½″ is placed in vertical position and the ends similarly shaped. This piece is also drilled with a 13/32″ drill.

Before assembling this lamp all finishing operations should be completed except those on the base and feet. The four feet should be assembled first. One machine screw may be used at either end of the ¾″ square posts instead of two small metal dowels. If only one metal dowel is used, the posts, except the one in the center, may turn around. One small dowel at the top or bottom will hold the center post. The lamp socket and pipe nipple ties the entire lamp together as a unit. Felt coverings on the plastics feet are not necessary if they are properly buffed and polished.



1/8 X 2 5/8 D. DISC
1/8 X 8 3/4 PIPE NIPPLE THREADED AT BOTH ENDS. LOCK NUT UNDER BOTTOM DISC
2 3/4 O.D. X 8 CYLINDER
3/16 X 5 3/8 D. DISC
1 RING FROM 5 5/8 CYLINDER
DRILL 5/16 HOLE FOR WIRE
TABLE LAMP

Plate 25

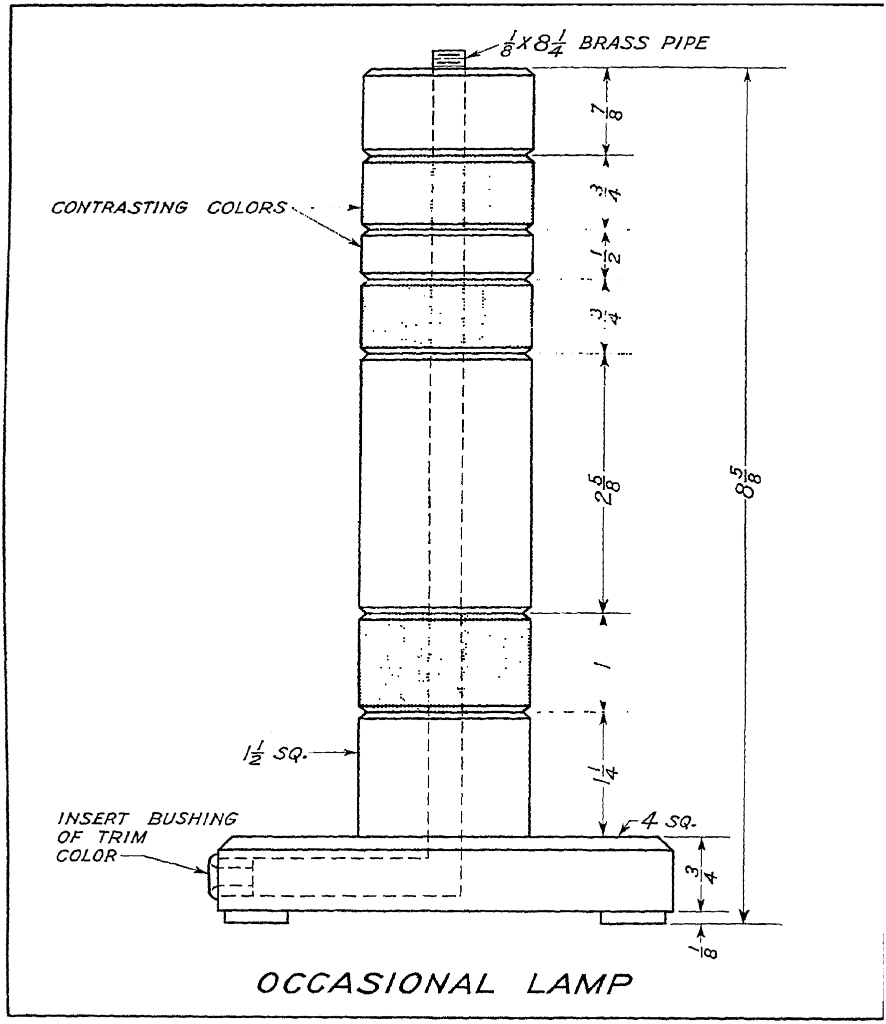
Plate No. 25

TABLE LAMP

A *table lamp* of unusual design is featured in the accompanying plate. Near hues or a black and white combination may be used. Before building this lamp, some study in division of space might be very much worth while. A review of Chapter 7 will give a better understanding of the problem involved. This large surface area must be broken up, yet it must be pleasing to the keenest observers.

The base of this lamp is a 1″ ring cut from a cylinder $5\frac{5}{8}$″ in diameter. To face up the sawed edges, place a sheet of abrasive paper on a flat surface and hold the ring against it, rubbing until a true surface is produced. If a machine lathe is accessible, the ring may be placed on the outside of the chuck jaws and faced off accurately. The jaws of the chuck should be expanded carefully in order not to exert too much pressure on the plastics ring. A narrow strip of cellulose acetate plastics .015″ in thickness is cut and cemented in place with acetate cement. The end joint should be very accurately done and sealed with cement. A disc $5\frac{3}{8}$″ in diameter is cemented to the top of this ring and a $\frac{13}{32}$″ hole drilled in the center. If equipment is available, a small bushing may be made and inserted for the entrance of the wire into the base.

The post is a cylinder $2\frac{3}{4}$″ in diameter and 8″ long with a $\frac{1}{8}$″ disc cemented to the top as shown. A $\frac{13}{32}$″ hole is drilled in the top plate for the pipe nipple. Strips of cellulose acetate .015″ in thickness are cut for the overlays. Positions should be determined for the overlays and the width of each noted carefully. In this particular design, the widest overlay is placed near the bottom, the next in width a little farther from the top, and the narrow one very close below the second. Rubber bands or clamps made of soft sheet metal may be used to hold the overlays until the cement sets. Buffing and polishing operations should be completed on the base and post before assembling. A nipple $8\frac{3}{4}$″ long with a lock nut on one end and a socket on the other will complete the assembly.



1/8 X 8 1/4 BRASS PIPE
7/8
3/4
1/2
3/4
2 5/8
1
1 1/4
8 5/8
CONTRASTING COLORS
1 1/2 SQ.
INSERT BUSHING OF TRIM COLOR
4 SQ.
3/4
1/8
OCCASIONAL LAMP

Plate 26

Plate No. 26

OCCASIONAL LAMP

This *occasional lamp* is made of solid blocks of plastics and has the appearance of a machine-made problem. Only a limited number of hand tools are necessary to make this lamp, but, as in most other projects, the accuracy with which operations are accomplished is very important. Here again we find the division of space and the balance of color presenting problems. One solution to this problem is suggested on the plate, but it is hoped that other divisions which will be even more attractive will be worked out.

The base material is $\frac{3}{4}''$ thick and is drilled and tapped in the center for a $\frac{1}{8}''$ brass nipple. By using the same drill and tap, a $\frac{1}{8}''$ hard rubber bushing may be inserted for the entrance of the wire through the base. Bushings are not necessary for wiring plastics lamps, except for a more finished appearance. Four blocks, $\frac{1}{8}'' \times \frac{5}{8}'' \times \frac{5}{8}''$, are used for feet and are set slightly in from the corners of the base. A $\frac{1}{8}''$ chamfer on the top arrises completes the base.

Seven blocks of $1\frac{1}{2}''$ square stock make up the post, four of the same color as the base and three a near hue. They should be cut square in a miter saw. A $\frac{1}{16}''$ chamfer is made on the ends of each block except the bottom of the first one. Holes $\frac{13}{32}''$ in diameter should be drilled through the center of each block. If these holes are not drilled accurately the blocks will not center and the post will not appear as one straight column. If a drill press is available it will help to solve the problem. The socket, when tightened down, will hold the lamp together firmly.

After the lamp has been assembled and errors corrected, if any, it should be taken apart and each piece finished separately. If cutting compounds are used with a buffing wheel, more than ordinary care must be taken not to rough any chamfered corners or remaining arrises. Failure to observe this precaution may spoil the entire effect of the design.

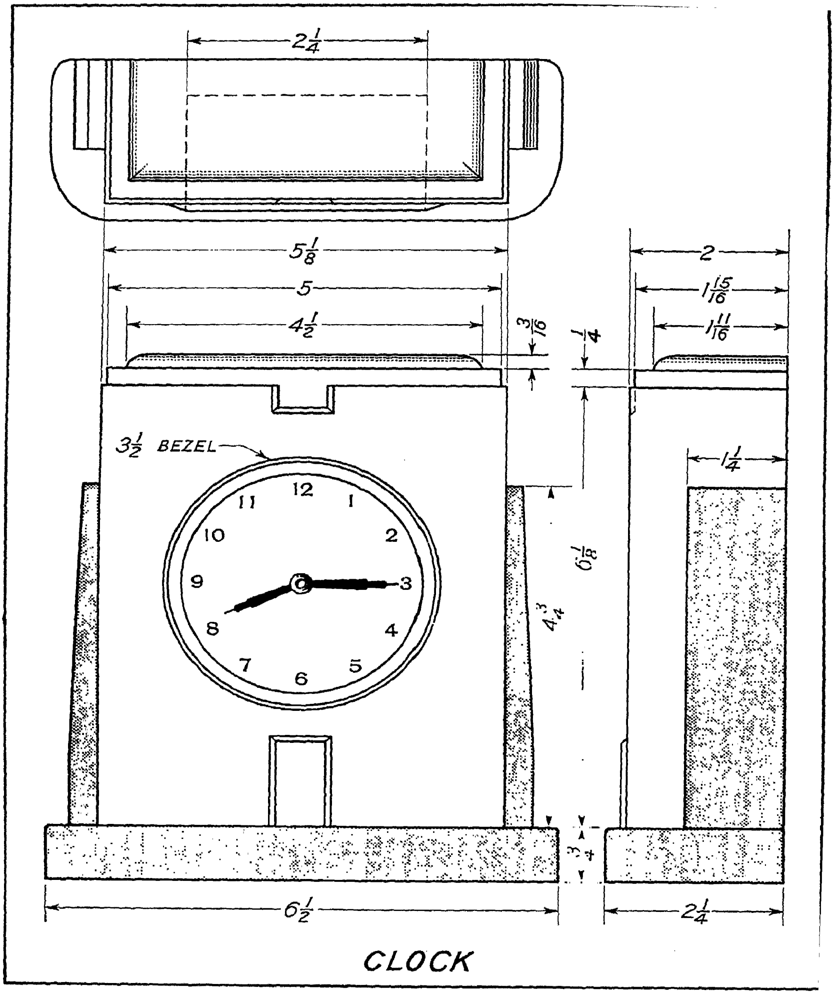

2 1/4
5 1/8
5
4 1/2
3/16
1/4
2
1 15/16
1 11/16
3 1/2 BEZEL
12
1
2
3
4
5
6
7
8
9
10
11
1 1/4
6 1/8
4 3/4
3/4
6 1/2
2 1/4
CLOCK

Plate 27

Plate No. 27

CLOCK

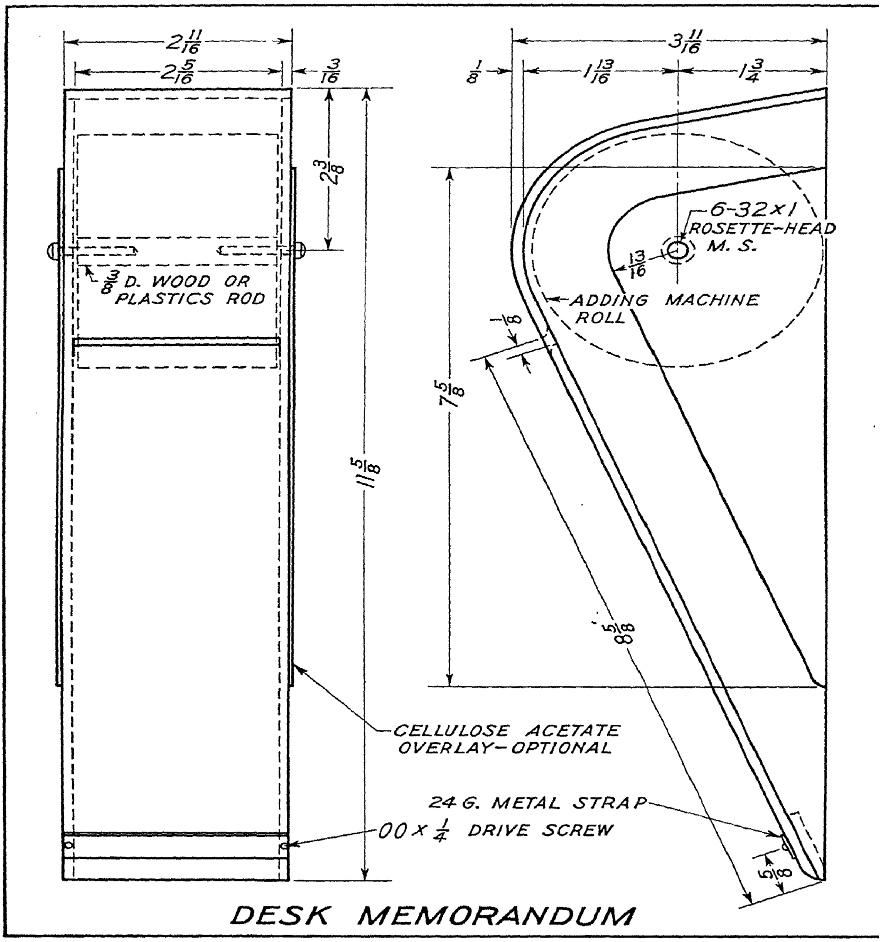
A useful and modernistic problem is illustrated in the accompanying plate. Before doing any work on this problem the size and type of movement should be decided upon. Electric or stem-wound, clock movements are on the market and many sizes are available in either type (see Appendix B). The clock to be used should be on hand in order that proper spacing and more accurate measurements may be taken.

The *clock* cabinet, as designed, is made of two carefully selected colors of cast resinoids. Stock $\frac{3}{4}''$ in thickness is used in the base and the top shows corner curves. A slightly rounded effect is given the top arris by using abrasive papers.

The front and ends are made of $\frac{1}{4}''$ material with cemented joints. In the center at top of the front section, a recess is cut with beveled edges. At the lower center of the clock face, a $\frac{1}{16}''$ overlay, with beveled edges to match the recess above, is cemented. Thrust pieces are cemented to the ends. These thrusts are placed flush with the back edge of the clock case.

The top consists of two rectangular pieces. One piece is cemented to the top with a $\frac{1}{16}''$ margin on three sides. The other piece with an elliptical shaped curve on three edges is cemented flush with the back. The case should be fastened to the base with machine screws.

Clock movements are usually adjustable to various thicknesses of material but not to material as thin as $\frac{1}{4}''$. To meet the requirements of almost any movement, a plywood back is fitted in the back of the case and blocked out from the front panel to the desired thickness. This problem offers an opportunity to combine wood and plastics in an effective setting. For this combination, we suggest the use of a solid block of choice cabinet wood for the main body of the case. The hue of the plastics parts selected for the base, side, and top will be determined by the kind and color of wood used.



$2\frac{11}{16}$
$2\frac{5}{16}$
$\frac{3}{16}$
$2\frac{3}{8}$
$\frac{3}{8}$ D. WOOD OR PLASTICS ROD
$11\frac{5}{8}$
CELLULOSE ACETATE OVERLAY—OPTIONAL
00 x $\frac{1}{4}$ DRIVE SCREW
$3\frac{11}{16}$
$\frac{1}{8}$
$1\frac{13}{16}$
$1\frac{3}{4}$
6-32 x 1 ROSETTE-HEAD M. S.
$\frac{13}{16}$
ADDING MACHINE ROLL
$\frac{1}{8}$
$7\frac{5}{8}$
$8\frac{5}{8}$
24 G. METAL STRAP
$\frac{5}{8}$
DESK MEMORANDUM

Plate 28

Plate No. 28

DESK MEMORANDUM

The *desk memorandum* provides a supply of note paper of any desired length in a convenient container. Paper is drawn from the front of an adding-machine roll through the slot and down under the metal strap. This strap serves two purposes: that of holding one end of the paper in place and that of a tear strip.

It is necessary to make a wooden form which will just fit the inside of the memorandum. A profile of this form should be identical with that of each side piece of the memorandum. This serves as a bending and clamping form for the cover strip. A piece of sheet metal is fastened to the bottom of one end of the form and is drawn tight around it to hold the plastic strip in place, either while cooling or while cement is setting.

When the top is ready to cement in place, the wooden form is covered with waxed paper so that cement will not stick to it. The two sides are held tightly against the form in a vise or clamp. Cement is applied to the joint and the parts are clamped in place. Both sides are smoothed and prepared for overlays. A thin sheet of "Celluloid" or "Lumarith" (.010″ to .025″ thick) may be used for overlays as indicated on Plate No. 28.

A roller should be cut from a $\frac{3}{8}$″ plastics rod slightly shorter than the thickness of the roll. Drill and tap both ends of the roller for a 6-32 x $\frac{3}{4}$″ machine screw. By adjusting these screws, proper tension can be given to the paper roll. A support strip of plastics is cemented in place at the lower end of the memorandum and the metal strap applied. Cut a slot for the paper to draw through and round both arrises. Complete the memorandum in the manner indicated.

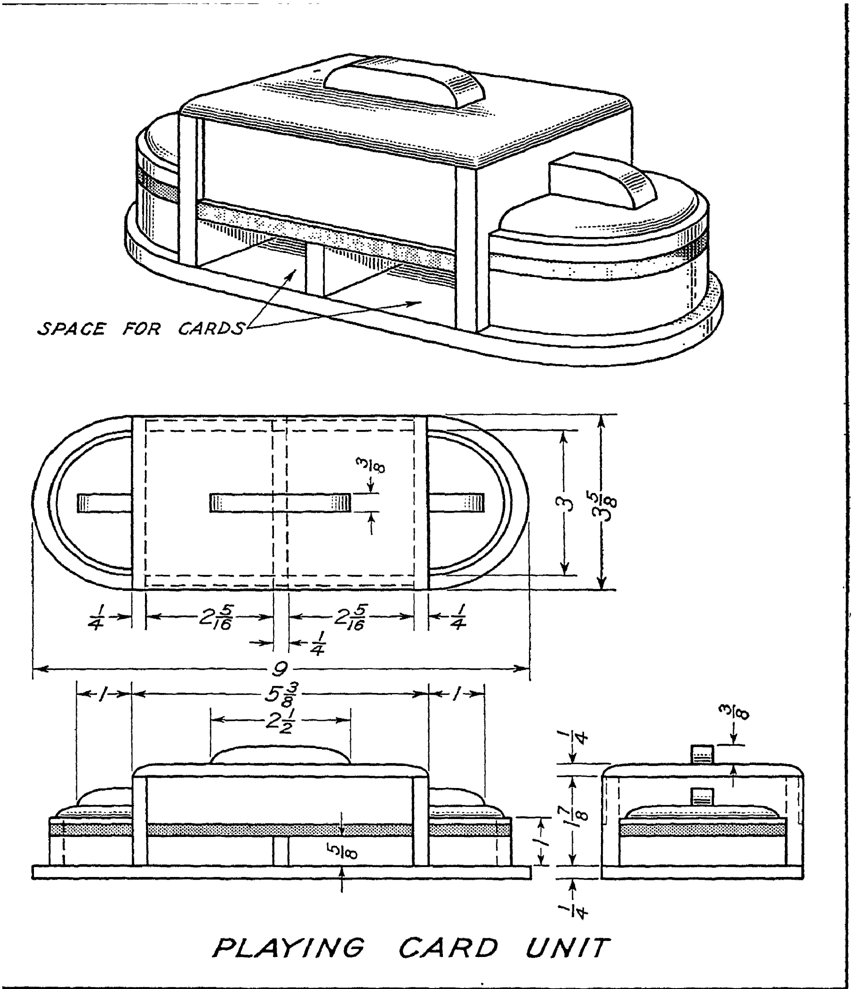

SPACE FOR CARDS
3/8
3
3 5/8
1/4
2 5/16
2 5/16
1/4
1/4
9
1
5 3/8
1
2 1/2
5/8
1/4
1 7/8
1
1/4
3/8
PLAYING CARD UNIT

Plate 29

Plate No. 29

PLAYING CARD UNIT

This *playing card unit* is designed as a major problem for anyone having had some experience in cutting, fitting, and assembling cast resinoids. This unit contains two spaces for cards open at either end, two semi-circular end compartments, and one larger rectangular section in the center. Only hand tools are necessary to execute all operations involved in making this unit, but a jig saw, disc sander, and power buffing wheels will solve many of the difficulties encountered.

Starting with the base, dimensions are given on the plate and the next step is to lay off and cut the four pieces which complete the spaces for two decks of cards. It is important to have these spaces exact, since the cards will fall out if they are too large, and if too small they cannot be used. Drive screws or self-tapping screws should be used to assemble these sections and if they are properly located they will be entirely concealed except under the base where they should be countersunk slightly. Two sides cut from ¼″ stock and fitted as shown, completes the center section to the cover. Small dowels and cement should be used in this assembly.

For the ends, a 1″ section of a 3″ diameter cylinder is cut in half. Cement should be used at the ends and screws of the same type as used in the bottom. A band of cellulose acetate ¼″ wide and .015″ in thickness is applied on the center section and carried around the semi-circular ends at the same height. Covers for the center and end sections have the same general construction. On the ends, a ⅛″ margin is left around the cover while on the top the entire surface is covered. To hold the covers in place a ⅛″ piece of plastics is fitted to the opening and then cemented to the top. Matched handles are shown and they should be anchored by machine screws. These same screws will also hold the laminated sections of the cover from slipping while the cement dries. Parts to be finished before and after assembling will be left to the worker.

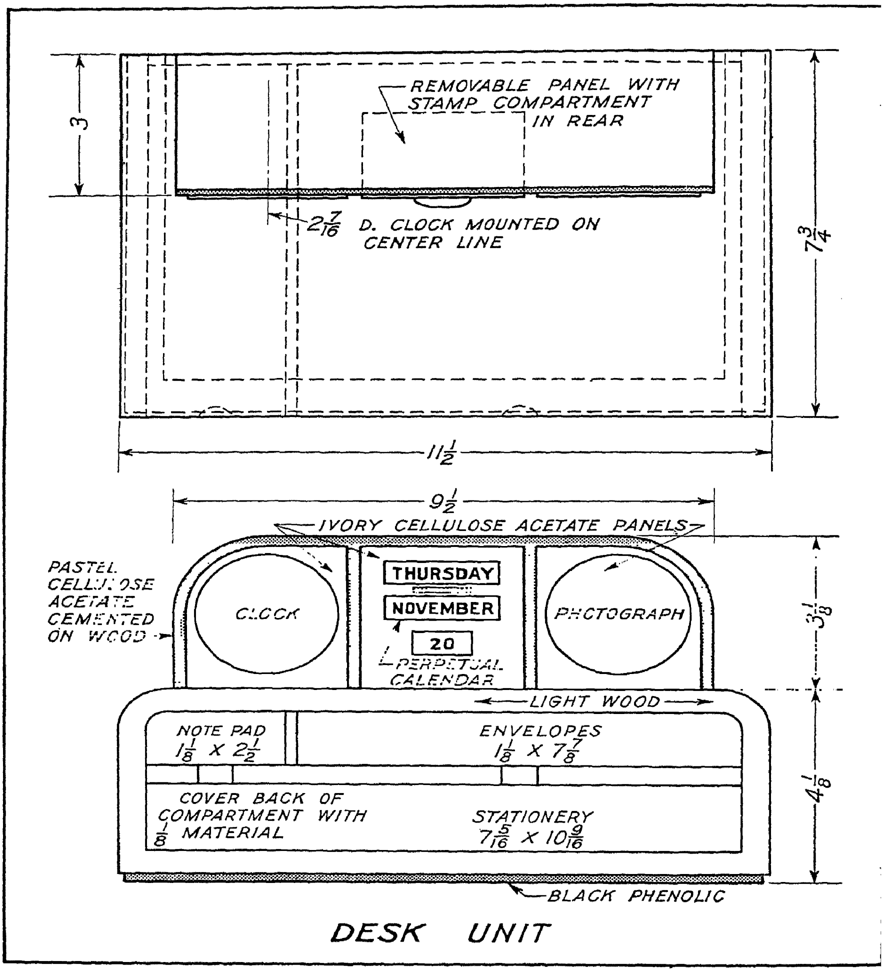

3
REMOVABLE PANEL WITH STAMP COMPARTMENT IN REAR
$2\frac{7}{16}$ D. CLOCK MOUNTED ON CENTER LINE
$7\frac{3}{4}$
$11\frac{1}{2}$
$9\frac{1}{2}$
IVORY CELLULOSE ACETATE PANELS
PASTEL CELLULOSE ACETATE CEMENTED ON WOOD
CLOCK
THURSDAY
NOVEMBER
20
PERPETUAL CALENDAR
PHOTOGRAPH
$3\frac{1}{8}$
LIGHT WOOD
NOTE PAD $1\frac{1}{8}$ X $2\frac{1}{2}$
ENVELOPES $1\frac{1}{8}$ X $7\frac{7}{8}$
$4\frac{1}{8}$
COVER BACK OF COMPARTMENT WITH $\frac{1}{8}$ MATERIAL
STATIONERY $7\frac{5}{16}$ X $10\frac{9}{16}$
BLACK PHENOLIC
DESK UNIT

Plate 30

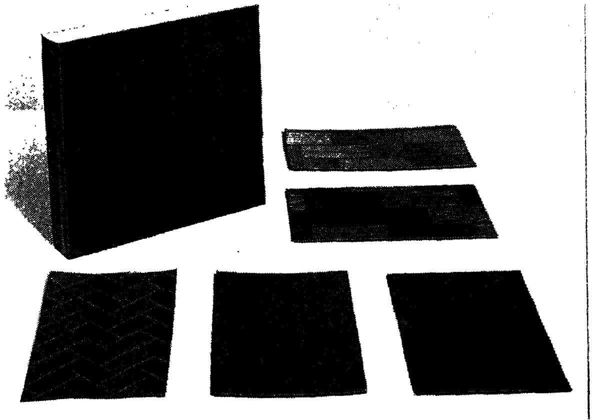


Figure 137. Sections from laminated plastics sheets.

Plate No. 30

DESK UNIT

The *desk unit* submitted here is an answer to a demand for a unit to serve more than one purpose. Seven or eight such units are combined in a space $7\frac{3}{4}'' \times 11\frac{1}{2}''$. To make this unit, the worker should have a previous knowledge of making rounded corners on wood cabinets and to be able to figure out difficult assembly problems.

Unlike most cabinets the top section is built first. This is done so that screws through the top of the lower cabinet can be used to hold it in place. The ends of this section should be built up so that the upper corners can be neatly shaped. The front is then covered with pastel cellulose acetate, over which the end panels of ivory cellulose acetate are cemented. For the center section, a removable panel of the same material is constructed. This also provides for the installation of a perpetual calendar behind the panel.

The lower section is built in much the same manner. It is $11\frac{1}{2}''$ long, $4''$ high and $7\frac{3}{4}''$ deep and is constructed of light wood. The corners should be built up on the inside and carefully rounded as shown. When this is complete the top section should be mounted in place, and the space divided into three sections as indicated. A light

wood veneer is applied over the entire front surface. This veneer should be trimmed and sanded even with all edges. Small arcs of circles are cut in the shelf to facilitate removing envelopes and note pads. A black phenolic trim (solid or narrow strips) forms the base.

Chapter 9

Machine-Work and Hand-Work Problems

THE INDIVIDUAL interested in the plastics craft will soon experience a desire to shape articles with the aid of machinery. Since individual and school users are often not supplied with an abundance of machinery, a combination of hand work and machine work will increase considerably the range of design and type of article which may be produced.

The machine work necessary on this group of problems is primarily lathe work. With a few exceptions, there is turning on all of the thirty-five problems. The exercises are grouped by similarity of usage.

The buttons and slides require rather simple mounting on special arbors and involve elementary turning processes. The bed lamp, on the other hand, requires chuck turning, arbor turning, and spindle turning perhaps. A woodworking lathe or a machine lathe with a woodworking attachment is the only machine necessary for many of the problems described.

One need not, however, limit himself to the use of a lathe. Many of the problems will be enriched by additional operations such as inlaying and carving. It is hoped that the suggestions brought together in this chapter will serve as a stimulus to all craftsmen who work with cast and laminated plastics and that more artistic creations will result from their efforts.

Additional machine equipment will suggest new uses for cast resinoids. A faceting machine will make possible intricate pieces of costume jewelry. Simple die-making equipment and a suitable press may provide, on the other hand, a possibility for quantity production of a few popular articles. The use of these and other machines adds interest to an already fascinating craft.

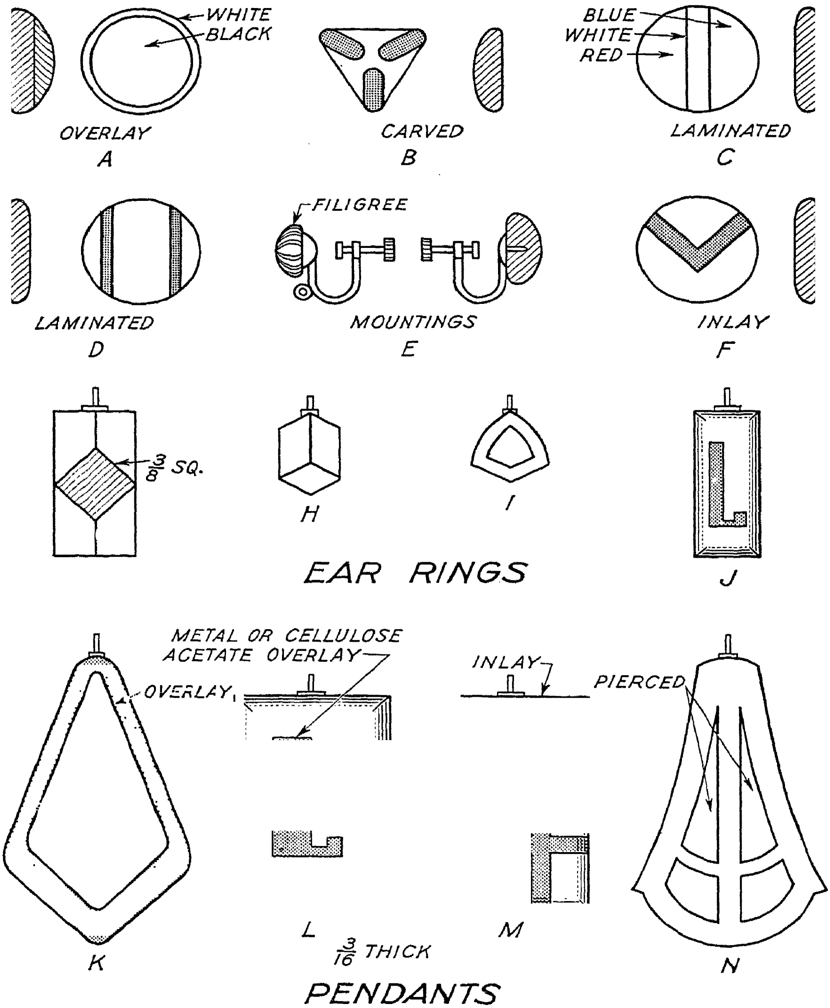

WHITE
BLACK
OVERLAY
A
CARVED
B
BLUE
WHITE
RED
LAMINATED
C
LAMINATED
D
FILIGREE
MOUNTINGS
E
INLAY
F
3/8 SQ.
H
I
EAR RINGS
J
METAL OR CELLULOSE
ACETATE OVERLAY
OVERLAY
INLAY
PIERCED
K
L
3/16 THICK
M
N
PENDANTS

Plate 31

Figure 138. Miscellaneous findings.

Plate No. 31

EARRINGS AND PENDANTS

Earrings and *pendants* require a minimum amount of material for their construction because they are in themselves very small articles. Designs which will require a maximum amount of work are suggested in order that an attractive article may be produced and economy

of material achieved at the same time. Scraps accumulating from other problems may be utilized. Oftentimes the size or color of a piece of scrap plastics will suggest a design.

There are three general types of earring mountings, two of which are shown on Plate 31-*E*. The mounting at the right is designed for plastics buttons similar to Plate 31-*A*, *B*, *C*, *D*, and *F* only. The mounting on the left has a filigree button and a small ring upon which is hung a small pendant similar to Plate 31-*G*, *H*, *I*, and *J*. A third type mounting (not shown) is like that on the right, Plate 31-*E*, except that a hinged-type clamp, instead of a screw-type clamp, is provided. When mounting the small metal pendant-ring findings to the small plastics pendants and the mountings to the small plastics buttons, it is necessary to drill a small hole (usually with a No. 66 or No. 67 drill) in the plastics so that the threaded finding can be screwed in place.

The pendants shown at the bottom of Plate 31 are designed to be worn for personal adornment by members of the fair sex. They are suspended from a chain which is worn about the neck.

METAL FINDINGS AND ACCESSORIES

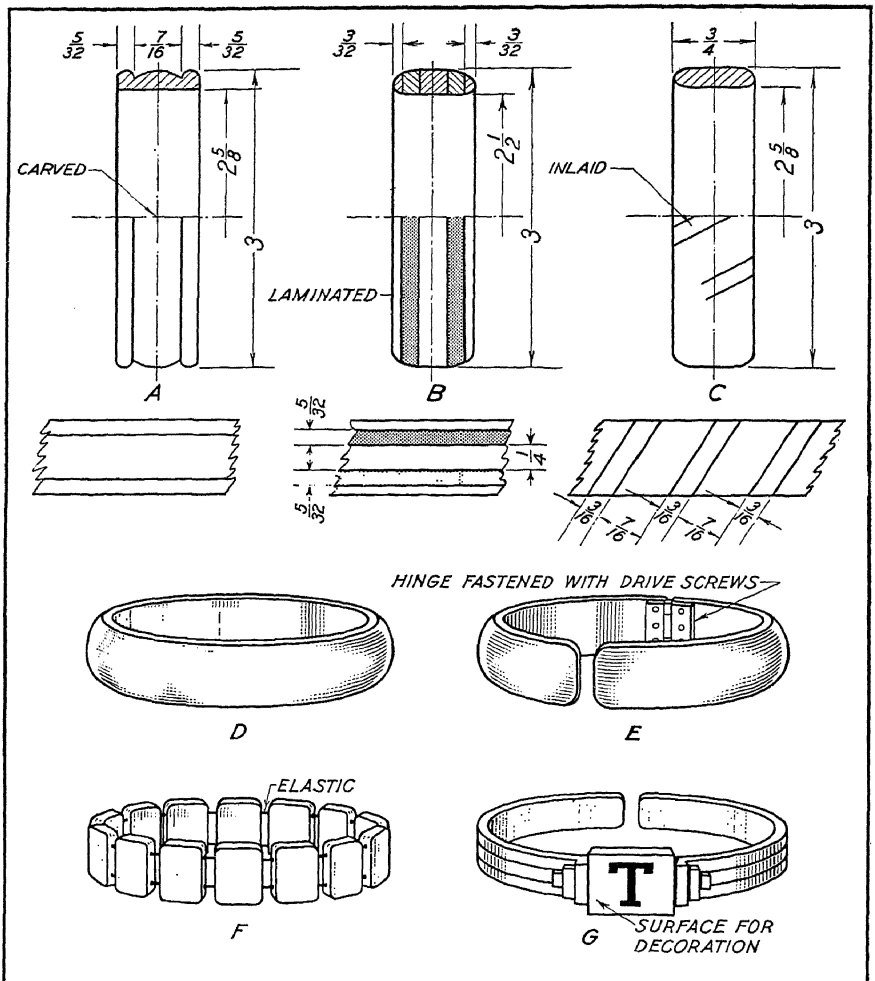
Manufacturers have recently made it possible to purchase findings in small quantities for almost any type of costume jewelry a craftsman elects to make (see App. B). Several different types of metal findings are illustrated in Figure 138. In most cases it is better to secure the findings before laying out the designs since various methods are used to fasten the fittings to the plastics surface. Some findings require the use of drive screws while other types have the screw or pin attached. Still another type is mounted on a piece of plastics in which case the use of cement is employed. This type is recommended where the plastics is too thin for use with drive screws or pins. In the case of clear or translucent plastics, screws and pins for fastening devices are not advised.

Miscellaneous accessories for costume jewelry and novelties included in Figure 138 are as follows:

Bag Staple
Bar Pins
Brass Chain
Brass Horseshoe Chain
Dress Clasp
Drive Screws
Ear Ring Mounting
Hair Pin
Hinge
Key Chain
Pendant Cap
Self-Tapping Screws
Snap
Spring Clasp
Spring Hinge
Spring Ring
Stick Pin
Strap Bar
Swivel Snap
Wick for Automatic Lighter

Other accessories and novelties not included in Figure 138 are:

Automatic Lighter Unit
Badge Pin
Buckle Catches
Electric Clock Movement
Jump Ring
Musical Units
Spring Clock Movement
Stick Pin and Broach Clip Combination



BRACELETS

Plate 32

Figure 139. Carving with rotary tool.

Plate No. 32

BRACELETS

The field of costume jewelry is passing into another stage of its development. Many years ago costume jewelry was made from precious metals and could be worn only by the rich. Then came a period during which costume accessories were made very attractive by using pressed shapes of cheap metals which were decorated with various finishes. With the gem-like plastics ornaments of today, the color is *in* and the finish is *on* the surface rather than *added to* it as used to be the case.

Solid bracelets are turned from a section of 3″ O.D. plastics cylinder. Laminated bracelets are made by cementing together several rings from different colored cylinders. When producing the laminations, accuracy in thickness is necessary. The bracelets are turned to size and shape while mounted on a mandrel or in a lathe chuck. Polishing should be done before the bracelet is removed from the lathe.

The hinged bracelet, Plate 32-*E*, is made from a special bracelet-tube casting. A hinge is mounted to the bracelet sections with drive screws. An elastic bracelet, Plate 32-*F*, is made from fourteen shaped, rectangular plastics pieces. Two holes are drilled and elastic cords are threaded through. The last bracelet, Plate 32-*G*, may be a section of

plastics cylinder or a strip of flat sheet bent to fit a wrist. A portion in the center is flattened and a special shaped ornament cemented in place. A necklace clasp is added to the chain in the back so that the necklace can be removed readily. Thin metal overlays such as initials, army and navy insignia, and the like, are available for mounting on pendants. The adhesive for mounting is on the back of the metal stamping.

UTILIZING WASTE MATERIALS

All craftsmen, hobbyists, and learners are confronted by problems arising with waste pieces which are cut from new and used stock. A thoughtless workman can easily consume in waste as much material as he uses. His reasoning is like that of the lad who, when he wished to obtain a 4″ diameter disc of basswood, cut it from the center of a 10″ x 28″ board.

An accumulation of small ends and corners of sheets, rods, and tubes occurs even when a worker carefully plans his work. This is especially true when large problems are designed and constructed. These odds and ends should be saved but they need not be thrown in a bin and forgotten. *Small* problems should be planned to use the *small* pieces. There need be very little waste because no part has to be discarded because the "grain runs the wrong direction" oftentimes as is the case with wood.

Many problems which require small dimension parts have been suggested to save the scrap material for a useful purpose. Bracelet F is made from fourteen plastics parts of the same hue or near hue. Sheet scraps are used here. Laminated bracelets (see Plate 32-B) may use small rings which have been left from making a shaving mug or flower vase, for example.

The problems on Plate 31 can be made, in most cases, from pieces taken from "waste" parts accumulated when sheets are cut for large problems. Tiny squares and rectangles left from thin sheet plastics may be used for overlays. Many experiments with color combinations may be made by cementing together short rod lengths for laminated rings, button, and other items of costume jewelry. Careful planning

of this nature helps a worker to reduce the quantity of his "shorts" which must be classed as *waste*. New and interesting problems at little cost reward his efforts.

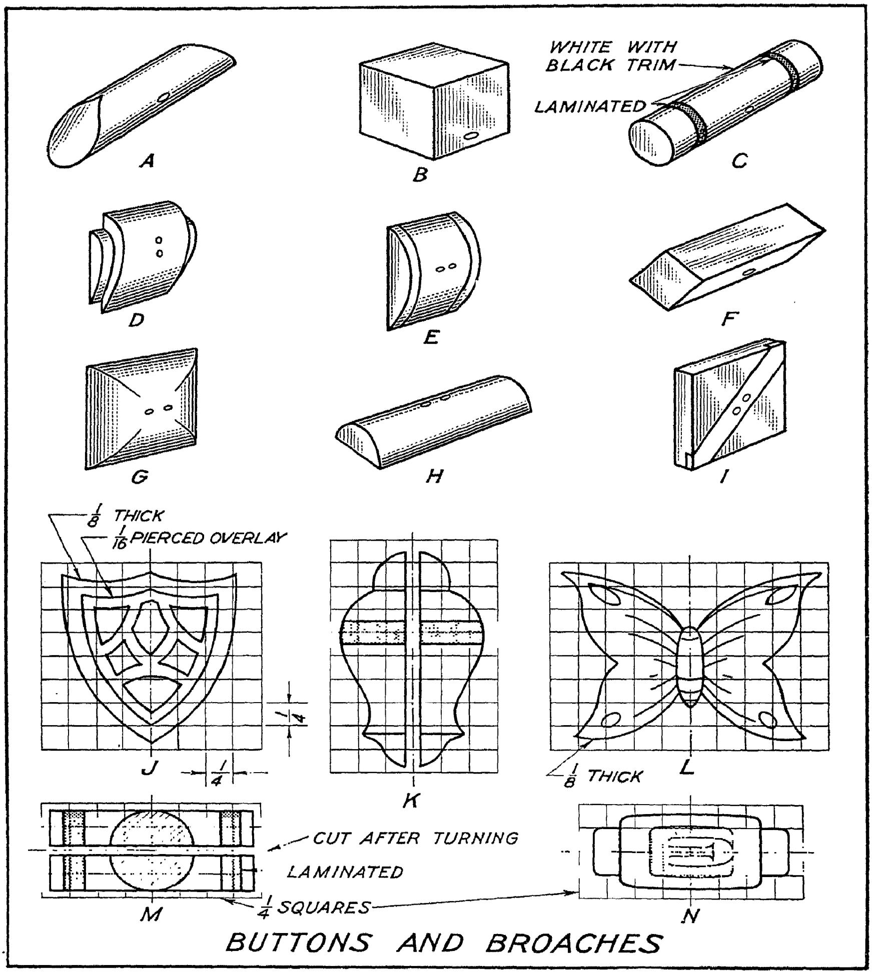
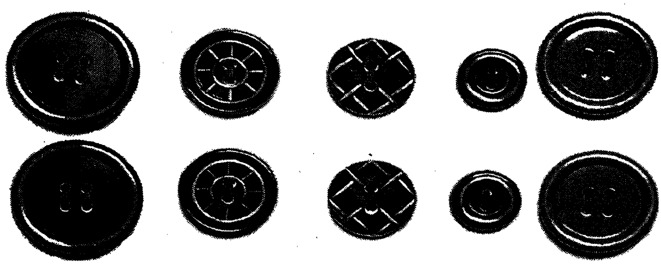

WHITE WITH
BLACK TRIM
LAMINATED
A
B
C
D
E
F
G
H
I
1/8 THICK
1/16 PIERCED OVERLAY
1/4
J
1/4
K
1/8 THICK
L
CUT AFTER TURNING
LAMINATED
1/4 SQUARES
M
N
BUTTONS AND BROACHES

Plate 33



(*Courtesy of the Consolidated Molded Products, Inc.*)

Figure 140. Buttons molded from "Lacanite."

Plate No. 33

BUTTONS AND BROACHES

Small pieces of plastics which would otherwise be wasted may be used for making the *buttons* and *broaches* shown on Plate 33. Buttons *C* and *E* are laminated, button *I* is inlaid, and all of the rest of the buttons are made of one piece of plastics.

All arrises on the buttons should be kept sharp until the buffing operations are started. Two small holes are drilled for eyes. The small portion between holes at the top surface of a button should be shaped with a graver to let the thread drop below the button surface. All surfaces should be buffed until all abrasive scratches are removed.

Broaches *K* and *M* are turned from a plastics rod and cut in half after the turning operation has been completed. These broaches may be laminated or may have a thin band of sheet plastics inlaid after shaping has been completed. After the broaches are cut in half, the halves are made thinner to reduce weight before a pin or clip is fastened to the back with drive screws. Broaches *J*, *L*, and *N* are cut to shape on a jig saw. A rotary tool may be used to add the line detail on broach *L*. All buffing on broach *J* should be done before the overlay is cemented in place. If a minimum of cement is used, no additional buffing will be necessary after the overlay is in place. The initial on broach *N* may be inlaid or overlaid.

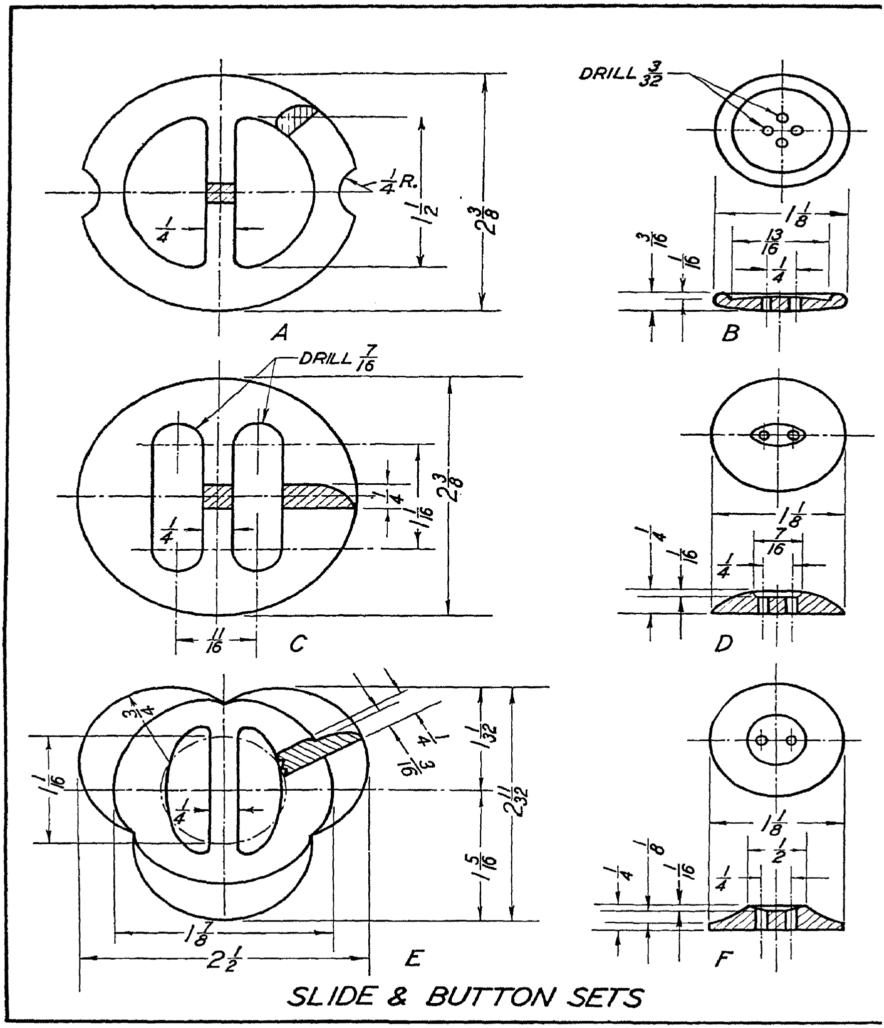

DRILL 3/32
1/4 R.
1 1/2
2 3/8
1/4
3/16
1/16
1 1/8
13/16
A
B
DRILL 7/16
11/16
1 1/16
C
7/16
D
3/4
1 1/32
3/16
2 11/32
1 5/16
1 7/8
2 1/2
1/8
1/2
E
F
SLIDE & BUTTON SETS

Plate 34

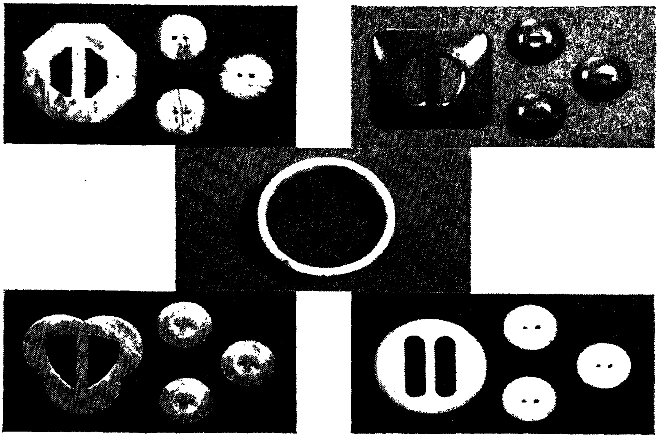


Figure 141. Bracelet and slide and button sets.

Plate No. 34

SLIDE AND BUTTON SETS

The separate parts of *slide and button sets* are made from rough-sawed discs of sheet plastics $\frac{3}{16}''$ or $\frac{1}{4}''$ thick. Accurate machine work begins with a turning operation. The section on "turning" in Chapter 5 should be reviewed. The buckles or slides are easily mounted on button and buckle arbors such as those shown in Figures 71 and 73. The necessary holes for mounting the buttons on the arbor are used later on for thread. Holes on each half of a slide must be drilled for inserting a saw blade so that the space for a dress belt may be cut. There is, therefore, no extra labor in preparing the problem for turning.

All layout work on buttons and slides should be completed before they are turned. After all lathe work has been finished, additional design may be provided by shaping with a jig saw. Button eyes are shaped with a hand carving tool or with a machine carving burr. All sharp arrises on the buttons and slides should be worked down to pleasing curves as indicated on Plate 34. Rotary tools, files, and abrasive sheets should be used for this purpose.

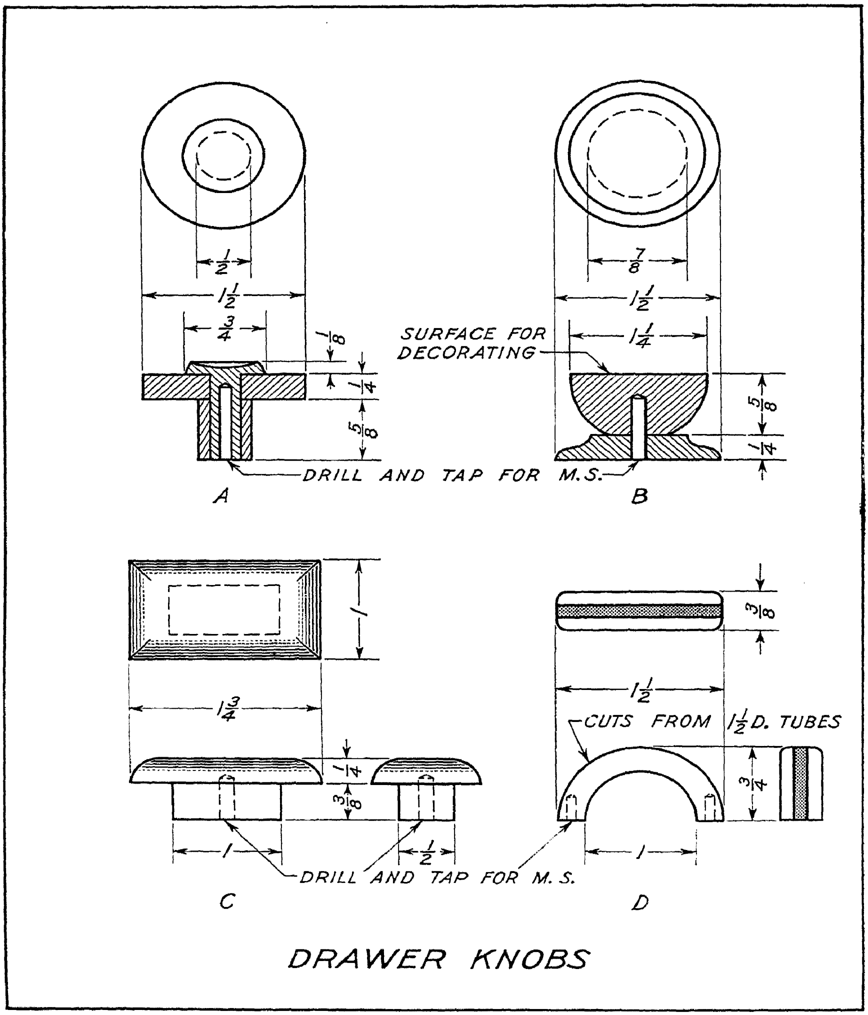

1/2
1 1/2
3/4
1/8
1/4
5/8
DRILL AND TAP FOR M.S.
A
7/8
1 1/2
SURFACE FOR DECORATING
1 1/4
5/8
1/4
B
1
1 3/4
1/4
3/8
1
1/2
DRILL AND TAP FOR M.S.
C
3/8
1 1/2
CUTS FROM 1 1/2 D. TUBES
3/4
1
D
DRAWER KNOBS

Plate 35

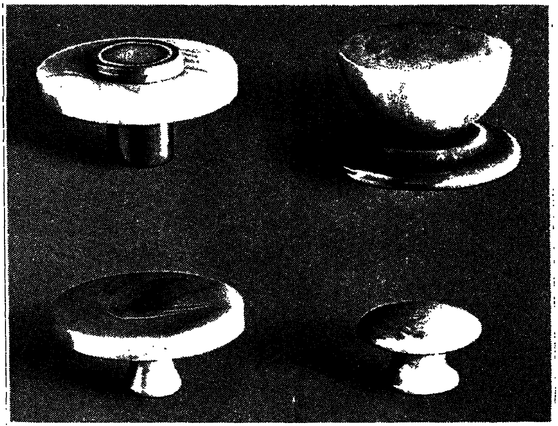


Figure 142. Drawer knobs.

Plate No. 35

DRAWER KNOBS

Two of the *drawer knobs* on this plate are entirely lathe problems and the other two are wholly hand problems. Knobs *A* and *B* are designed as parts of sets which include two drawer pulls on Plate 36. If they are to be constructed in sets, this fact should be kept in mind when selecting color combinations.

Knobs *A* and *B* are mounted for turning on machine-screw arbors (see Figure 72). All sanding and polishing operations should be completed before the knob parts are removed from the lathe mounting. Knob *C* is made from a shaped slab of plastics and a short length of square rod. The parts are cemented together. Knob *D* is laminated from three sections cut from plastics cylinders. When the rings are cemented and cut apart a *pair* of knobs is produced. All knobs are drilled and tapped for machine screws so that they can be mounted securely on doors or drawers.

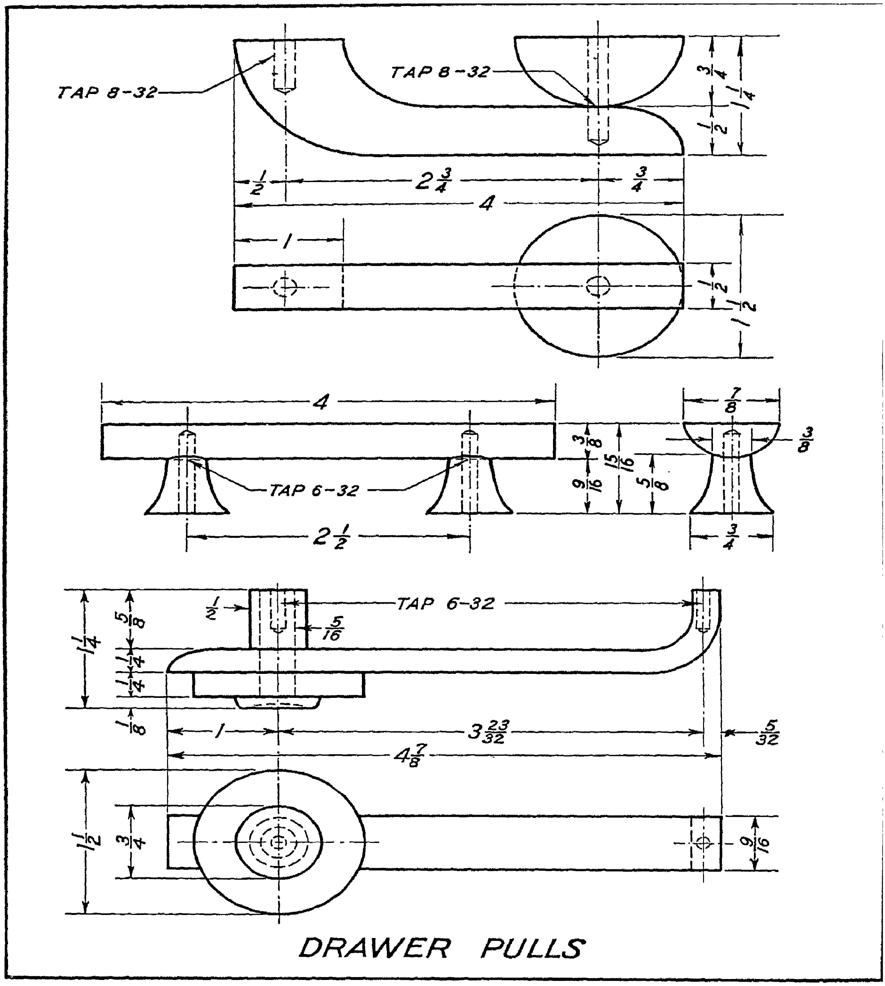


Plate 36

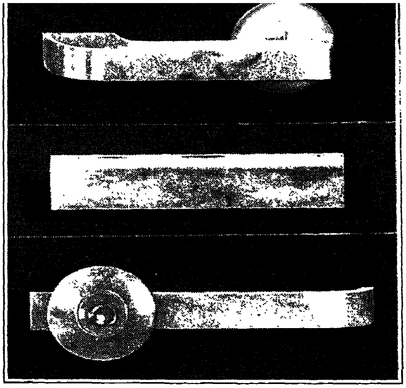


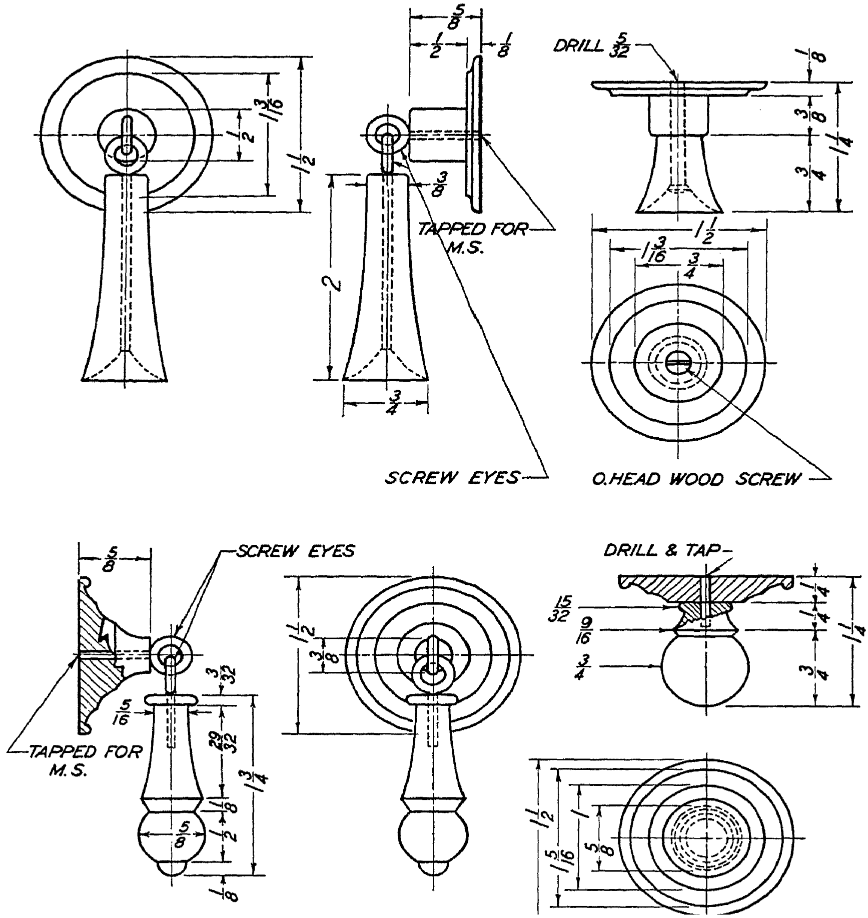
Figure 143. Drawer pulls.

Plate No. 36

DRAWER PULLS

The reader should note the difference between the two groups of designs for *drawer pulls.* The designs in Figure 143 are governed by *use* and by *stock sizes* of cast resinoids. Designs for molded drawer pulls are limited only by *use* and by *die limitations.*

Bending and sawing operations for these problems are added to the turning operations common to the problem on Plate 35. A bending form is necessary for the first drawer pull (see Chapter 4). A handle for another pull is sawed from a $\frac{7}{8}''$ D. rod. Each half makes one handle for a pair of pulls. A piece of $\frac{1}{4}''$ sheet plastics is necessary for the handle on the third drawer pull. All circular parts are mounted on arbors for turning. All arrises should be kept sharp until parts are ready for buffing operations. At that time they may be rounded slightly to produce a pleasant feel on the completed pull.



CABINET SETS

Plate 37

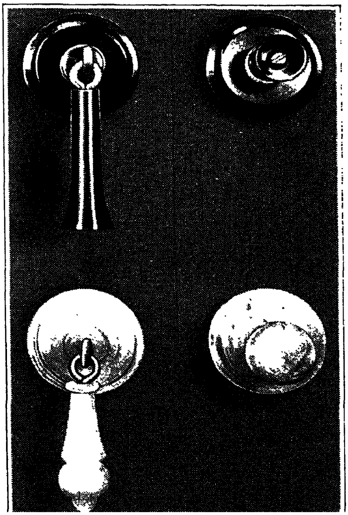


Figure 144. Cabinet sets.

Plate No. 37

CABINET SETS

The *cabinet sets* illustrated are designed for kitchen cabinets or similar articles. All parts are turned while mounted on special arbors (see Figure 72). Individual pieces in the sets are made up of two or more separate plastics parts. Combinations of color are, therefore, permitted without cemented joints.

Two screw eyes provide a necessary swivel joint. If a machine-screw eye can be obtained, it is most satisfactory; otherwise wood-screw eyes may have machine-screw threads cut on them. If neither of these is available, a length of soft brass rod can be bent with a loop at one end, hardened, and the straight portion threaded to serve the purpose. All handles are fastened to drawers or doors with machine screws.

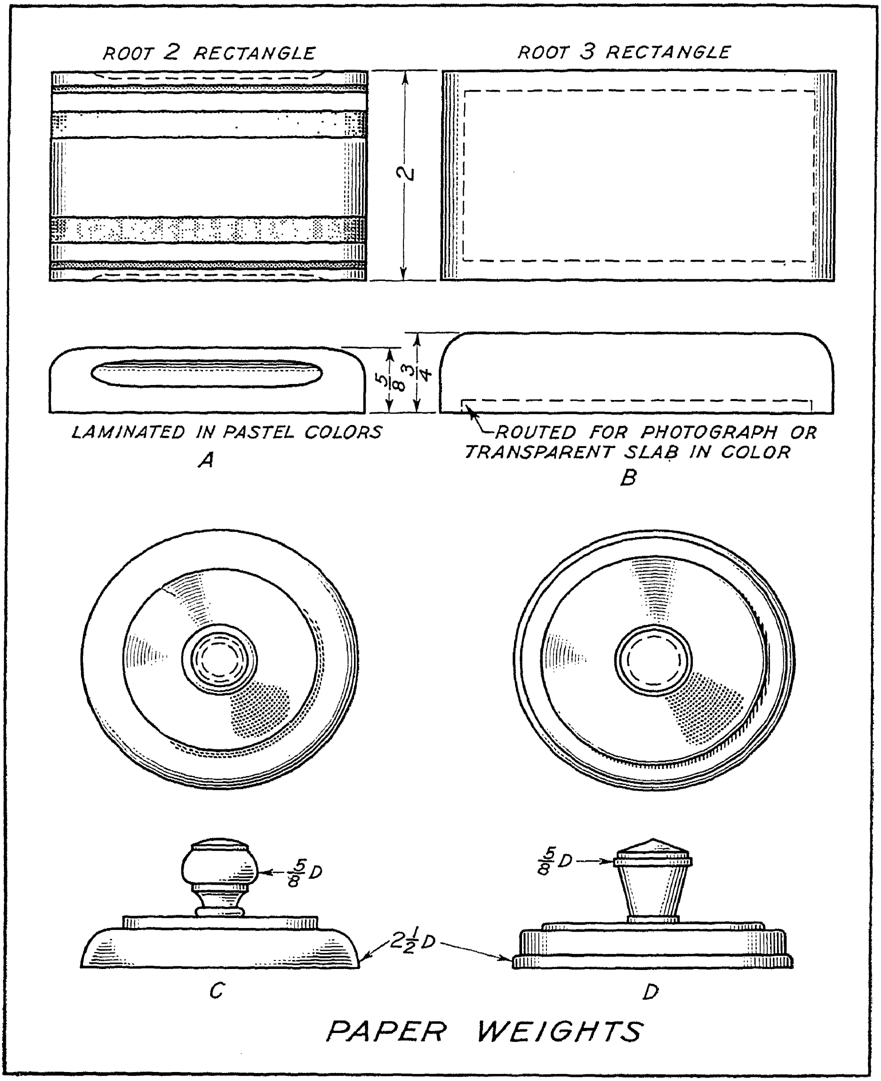

ROOT 2 RECTANGLE
ROOT 3 RECTANGLE
2
5/8
3/4
LAMINATED IN PASTEL COLORS
A
ROUTED FOR PHOTOGRAPH OR
TRANSPARENT SLAB IN COLOR
B
5/8 D
5/8 D
2 1/2 D
C
D
PAPER WEIGHTS

Plate 38

Plate No. 38

PAPER WEIGHTS

A rectangular solid is the basis for the designs used on *paper weights A* and *B*. Both designs start with the same width, but two lengths are specified—root-2 and root-3 rectangles (see Figure 118). These specifications should insure rectangles of pleasing proportions. Paper weight *A* should not be made in a root-3 proportion since the horizontal lines from the laminations give an appearance of added length. After all shaping has been done on the body of the laminated weight, the shallow grooves for finger grips should be added with a carving chisel. Abrasive paper over a dowel may be used to remove tool marks.

Paper weight *B* is shaped from a rectangular slab of transparent plastics. The bottom is routed to make way for a photograph or a colored piece of transparent plastics. If the routing is accurately done, an attractive variation from a plain slab may be produced. The photograph or transparent slab is cemented in place. The whole base may be covered with felt, if the bottom is to be made opaque.

With the exception of a few minor laying-out and finishing operations, paper weights *C* and *D* are exclusively lathe problems. Knobs are turned from short lengths of plastics rods mounted on machine-screw arbors (see Figure 72). Parts for the bases of these two weights are cut to rough disc shape, centered, drilled, and tapped for a machine screw. A single piece may be used for each base or separate pieces may be used at each offset. All base parts are mounted on an arbor for turning. The paper weights may be left with a sanded surface on the bottom or felt may be cemented on to prevent them from sliding off papers too easily.

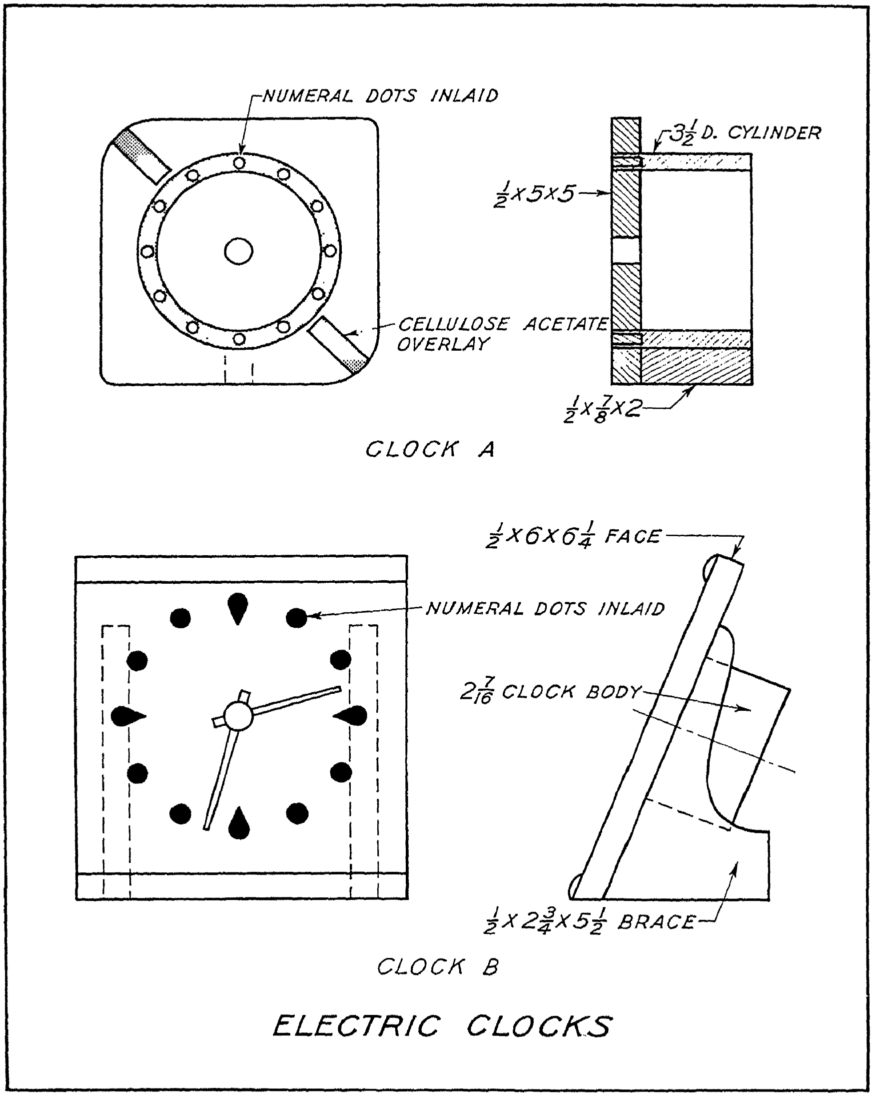

NUMERAL DOTS INLAID
$3\frac{1}{2}$ D. CYLINDER
$\frac{1}{2}$x5x5
CELLULOSE ACETATE OVERLAY
$\frac{1}{2}$x$\frac{7}{8}$x2
CLOCK A
$\frac{1}{2}$X6X$6\frac{1}{4}$ FACE
NUMERAL DOTS INLAID
$2\frac{7}{16}$ CLOCK BODY
$\frac{1}{2}$X$2\frac{3}{4}$X$5\frac{1}{2}$ BRACE
CLOCK B
ELECTRIC CLOCKS

Plate 39

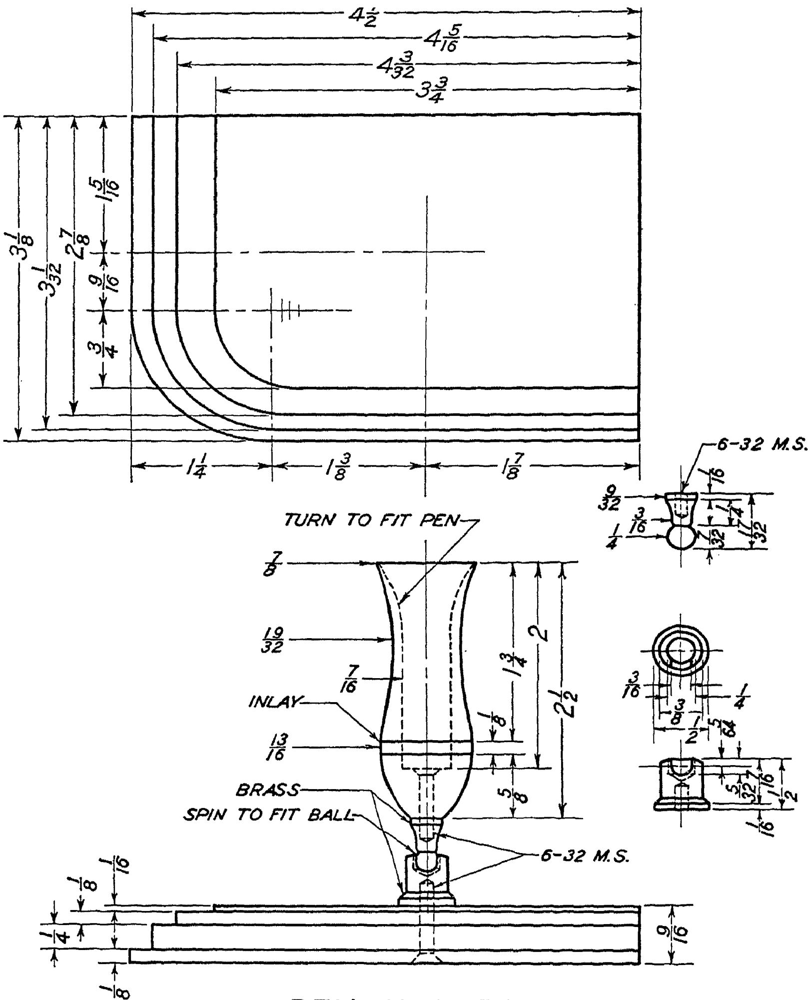
Plate No. 39

ELECTRIC CLOCKS

The *electric clock* frames shown on this plate are designed for the newer type clocks which have no bezels or dials when they are obtained from a supply house (see Appendix B). The clock dials are made on the plastics surface and only the clock hands project through the plastics dial. By varying the size of the cylinder used to enclose the clock body, the clock case can be adapted to almost any electric clock on the market.

The dial on clock *A* is placed in the center of the face because of the nature of the design. The face slab is centered and mounted on a heavy machine-screw arbor. A groove is turned to conform to the size of a $3\frac{1}{2}''$ D. plastics cylinder. Before the cylinder and face parts are cemented together, the numeral dots should be laid out. When the parts are cemented together, the cylinder should project through slightly. Drill holes for the numeral dots and cement short lengths of plastics rod in place. The whole face is then sanded flat. This clock case may be adapted for wall use or desk use. A picture frame hanger may be fastened to the back end of the cylinder and the clock hung on a wall. The small rectangle of plastics at the bottom of the cylinder is cemented in place to hold the clock in a vertical position when it is set on a desk. After all sanding and buffing operations are completed, two small acetate overlays are cemented in place.

Clock *B* is designed for desk use. Five plastics parts are necessary for the clock case, unless the numeral dots are inlaid in solid plastics. Two braces are necessary to support the clock face. They are cut out and cemented in place or fastened with self-tapping screws. Holes for the numeral dots are drilled. Four holes require extra shaping, or a larger dot will serve the same purpose. The holes may be inlaid with colored plastics rods or with colored plastics cement. In either case, the inlay should project slightly above the surface so that the holes will be filled when sanding is done. When the face has been smoothed, the curved strips at the top and bottom of the clock face are cemented in place. A hole is drilled in the face for mounting the clock movement. It should be noted that the clock dial is slightly above center on the face.



PEN HOLDER

Plate 40

Plate No. 40

PEN HOLDER

The *pen holder* in the accompanying illustration is adjustable to any angle. It will, therefore, lie down flat for packing. The fountain pen which is to be used in the holder should be secured before the pen socket is turned, since dimensions of pen stocks will vary. A pocket pen may be used providing a pointed end of colored plastics to blend with the pen holder is turned for it.

Stock for the base may be cut from a slab of plastics $\frac{5}{8}''$ thick or it may be built up from a number of thin sheets. It should be noted that the diagonal of the rectangular base is the determining factor in obtaining sizes for all set backs shown, as may be seen in Figure 118 (G). If a solid slab of plastics is used, a router placed in a drill press will produce the necessary edge cuts.

Accurate fitting around the ball-and-socket joint is necessary if the joint is to work with proper tension. The brass ball should be turned in a lathe so that it will be symmetrical and so that it will not bind in certain positions and be too loose in others. Machine-screw arbors (see Figure 72) may be used for mounting all parts for turning.

The pen socket can be turned by mounting on the lathe in one of two ways: (1) it can be held in a lathe chuck until all inside drilling, turning, and polishing are done and then mounted on a machine-screw arbor, or (2) it can be mounted on a machine-screw arbor at the beginning and supported at the head stock by a small lathe chuck. Support from the dead center should be used in either case while all outside turning is being done. As soon as the pen hole has been drilled, a wooden bushing can be used against the dead center.

No arris should be worn out of shape during buffing operations. A point for the holder is located by an intersection of diagonals on the top plane. Just before all parts are fastened together, the brass ball should be placed in the holder base and the edge spun tight over the ball. Two machine screws are necessary for assembling the other parts.

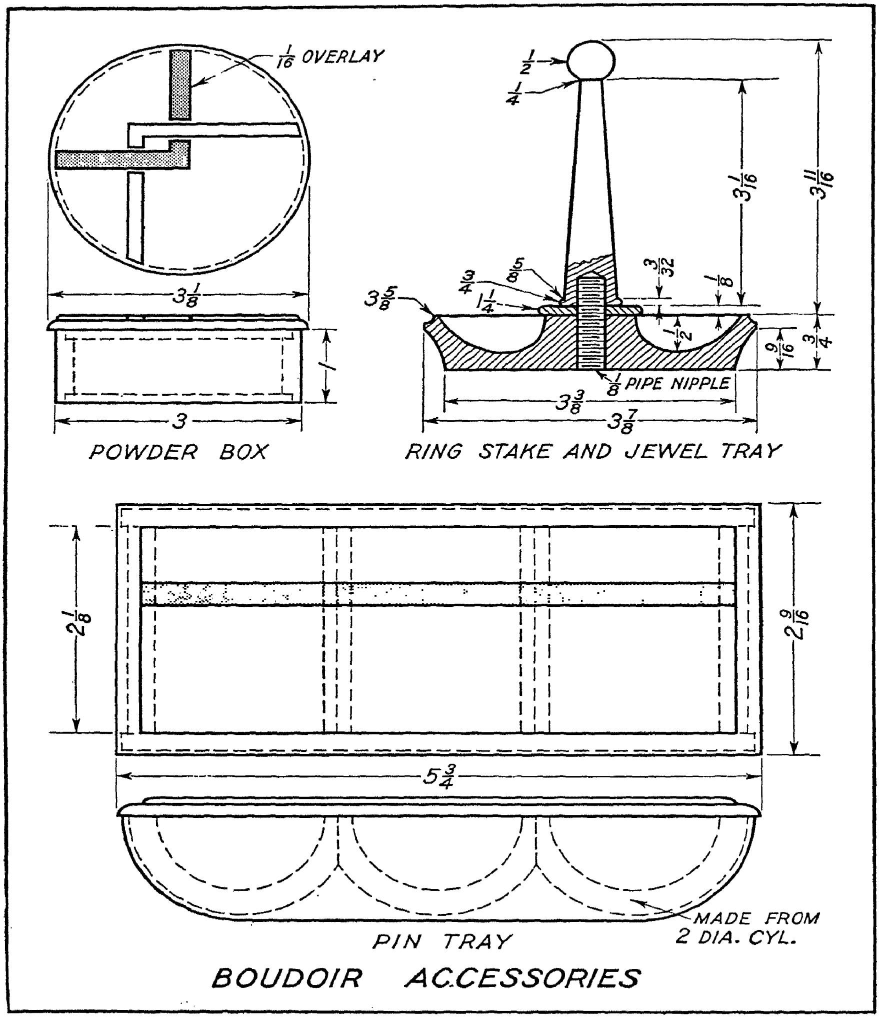

1/16 OVERLAY
3 1/8
1
3
POWDER BOX
1/2
1/4
5/8
3/4
1 1/4
3 5/8
3/32
1/8
3 1/16
3 11/16
1/2
9/16
3/4
1/8 PIPE NIPPLE
3 3/8
3 7/8
RING STAKE AND JEWEL TRAY
2 1/8
2 9/16
5 3/4
MADE FROM
2 DIA. CYL.
PIN TRAY
BOUDOIR ACCESSORIES

Plate 41

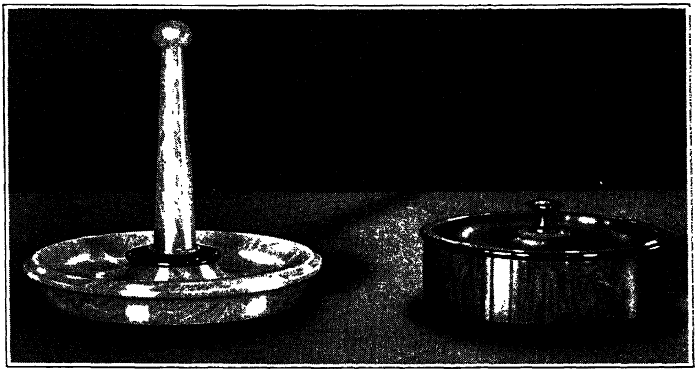


Figure 145. Ring stake, jewel tray, and powder box.

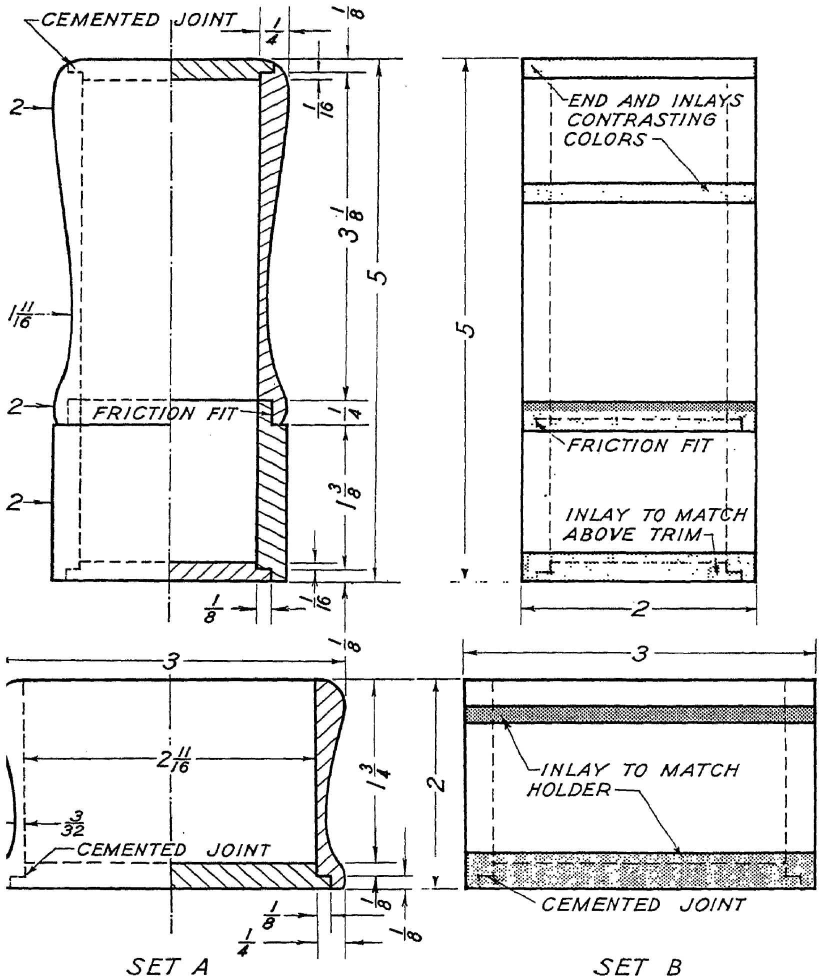
Plate No. 41

BOUDOIR ACCESSORIES

A cylinder section used on the *powder box* should be mounted in a lathe chuck for turning. The box bottom can be mounted on a machine-screw arbor for turning to accurate dimensions. The hole made for the machine screw is then drilled and a small rod is cemented in the hole. The box top may be held in a lathe chuck readily since there are two diameters. The overlay strips should be of thin plastics and near hues. The overhanging top is easily picked up.

The three parts for the *ring stake and jewel tray* are all turned while mounted on a machine arbor which has been fitted with a $\frac{1}{8}''$ pipe nipple. The type of assembly shown on Plate 41 enables the parts to be disassembled quickly in case of breakage.

The *pin tray* is made from three sections of half cylinders. Where these sections are joined in the center, a portion is flattened on a disc sander. The sections are cemented together, their ends are sanded even, and the two side pieces are cemented in place. The cover is made last. Three strips of thin plastics are added to the top of the cover for color variation. Small strips must be cemented to the under side of the cover to hold it in place on the tray.



BRUSH TUBES AND SHAVING MUGS

Plate 42

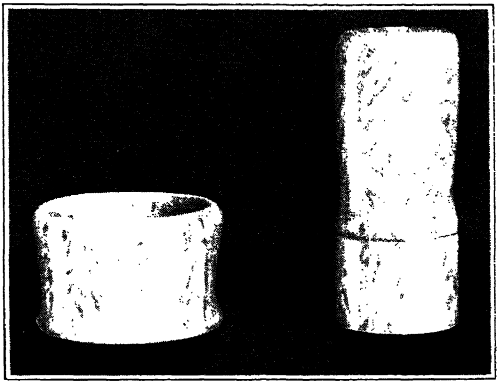


Figure 146. Shaving mug and brush tube.

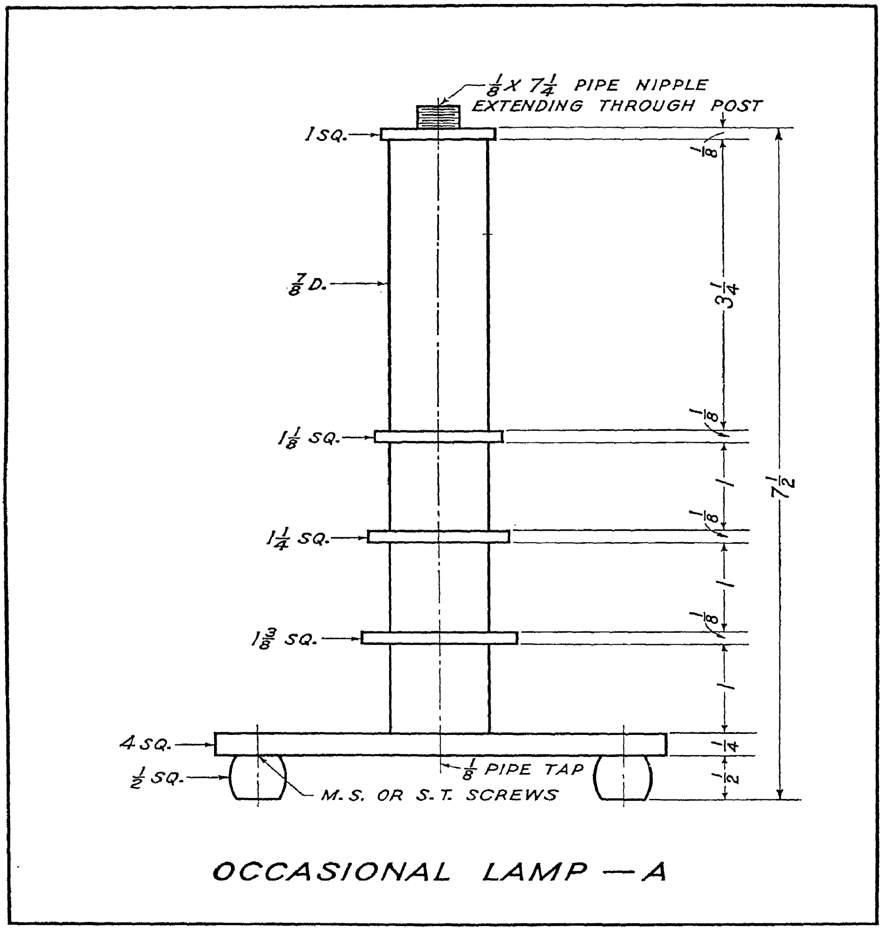
Plate No. 42

BRUSH TUBES AND SHAVING MUGS

All of these articles should be waterproof because of the nature of their use. Most plastics materials have a very low moisture absorption rate, therefore there is no problem from that angle. Carefully fitted and cemented joints are necessary for good appearance and practical usefulness.

Dimensions shown for the *brush tubes* provide sufficient length for an average-sized shaving brush. A close-fitting joint at both ends of the brush tubes is necessary so that the joint will be inconspicuous. The friction fit where the two parts come together is necessary so that the tube will not come apart when carried in a traveling bag.

A section of a 3″ plastics cylinder may be used for *shaving mugs.* There is ample space on the inside for a cake of shaving soap. A lathe chuck of three-inch capacity (or larger) simplifies the turning operations on this problem.



1/8 X 7 1/4 PIPE NIPPLE
EXTENDING THROUGH POST
1 SQ.
7/8 D.
1 1/8 SQ.
1 1/4 SQ.
1 3/8 SQ.
4 SQ.
1/2 SQ.
1/8 PIPE TAP
M.S. OR S.T. SCREWS
1/8
3 1/4
1/8
1
1/8
1
1/8
1
1/4
1/2
7 1/2
OCCASIONAL LAMP — A

Plate 43

Plate No. 43

OCCASIONAL LAMP—A

This *occasional lamp* has been designed with simplicity, ease of construction, and minimum of material in mind. Cylinders and squares are combined in the post. A slight curvature is added to the sides of the feet to break the monotony of straight lines. All parts are made from standard sized castings and very little shaping is required. Because of the simplicity of design, a beginner in the plastics craft need have no difficulty with this problem.

All of the squares in the post, and the large one for the base, should be marked out with scribed lines on plastics sheets before any cutting is done. Make sure that one straight edge exists as a working edge. Cutting should be done on the waste side of the scribed lines so that work to accurate dimensions is possible. Cutting of waste material down to the scribed lines may be done on a disc sander or with a hand file. The edges of the base square may be smoothed with a block plane. When all squares are cut and sanded to accurate dimensions, they should be centered and drilled—those in the post to $\frac{13}{32}''$ D. and in the base to $\frac{21}{64}''$ D. and tapped with a $\frac{1}{8}''$ pipe tap.

The four lengths of rod for the post may be cut from a long section of plastics rod or from several short lengths. Color variation is possible when a shift is made from the square to a cylinder. If a machine lathe is available, the rods should be machined to accurate domensions, center drilled, and $\frac{13}{32}''$ holes drilled while they are in the lathe chuck. If no lathe is available, the rods may be squared off to length on a disc sander and drilled by hand or on a drill press. All arrises must be sharp so that they will fit the squares accurately.

The feet start as cubes and have a smaller square marked off on opposite ends. With a file or disc sander, the curvature is added to each side. Sanding with fine abrasive paper will remove all tool marks or coarse scratches. Since the feet must be drilled and tapped for fastening to the base, they may be mounted on a machine-screw arbor for final sanding and buffing. All parts of the lamp are held together by the $\frac{1}{8}''$ pipe nipple.

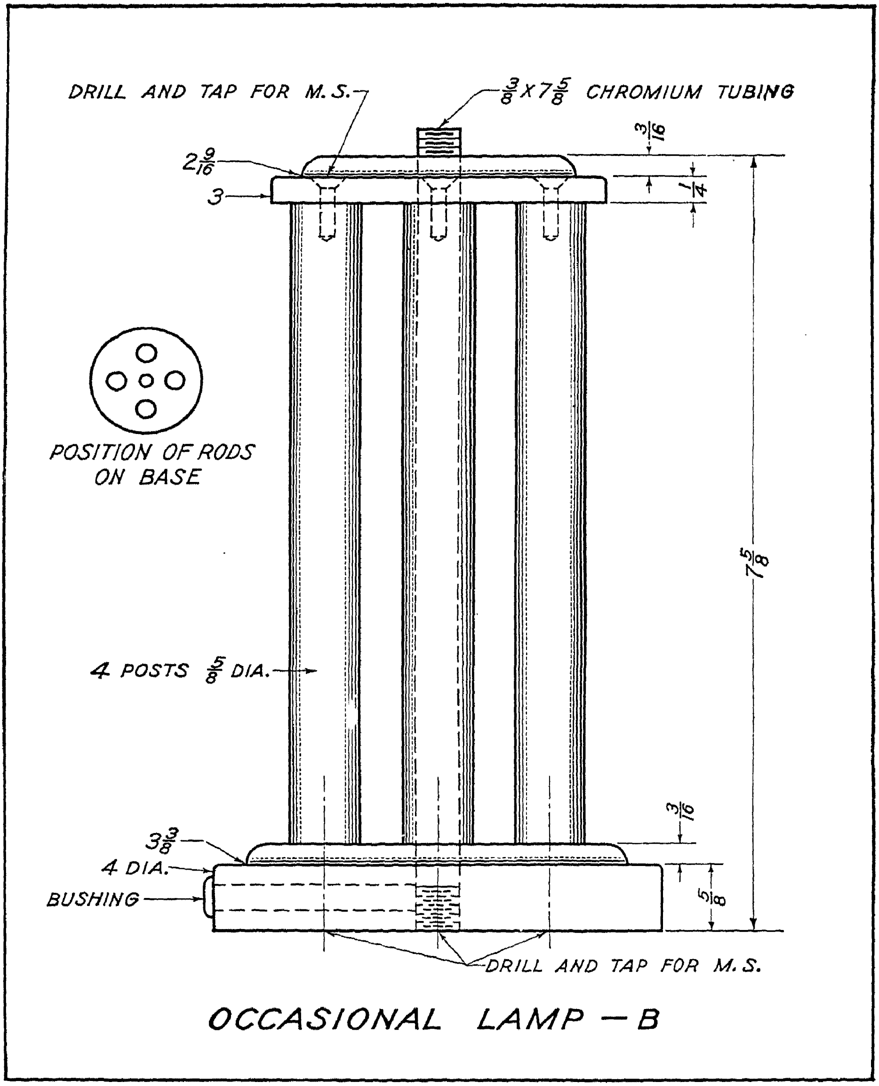

DRILL AND TAP FOR M.S.
$\frac{3}{8}$ X $7\frac{5}{8}$ CHROMIUM TUBING
$\frac{3}{16}$
$2\frac{9}{16}$
3
$\frac{1}{4}$
POSITION OF RODS ON BASE
$7\frac{5}{8}$
4 POSTS $\frac{5}{8}$ DIA.
$\frac{3}{16}$
$3\frac{3}{8}$
4 DIA.
BUSHING
$\frac{5}{8}$
DRILL AND TAP FOR M.S.
OCCASIONAL LAMP — B

Plate 44

Plate No. 44

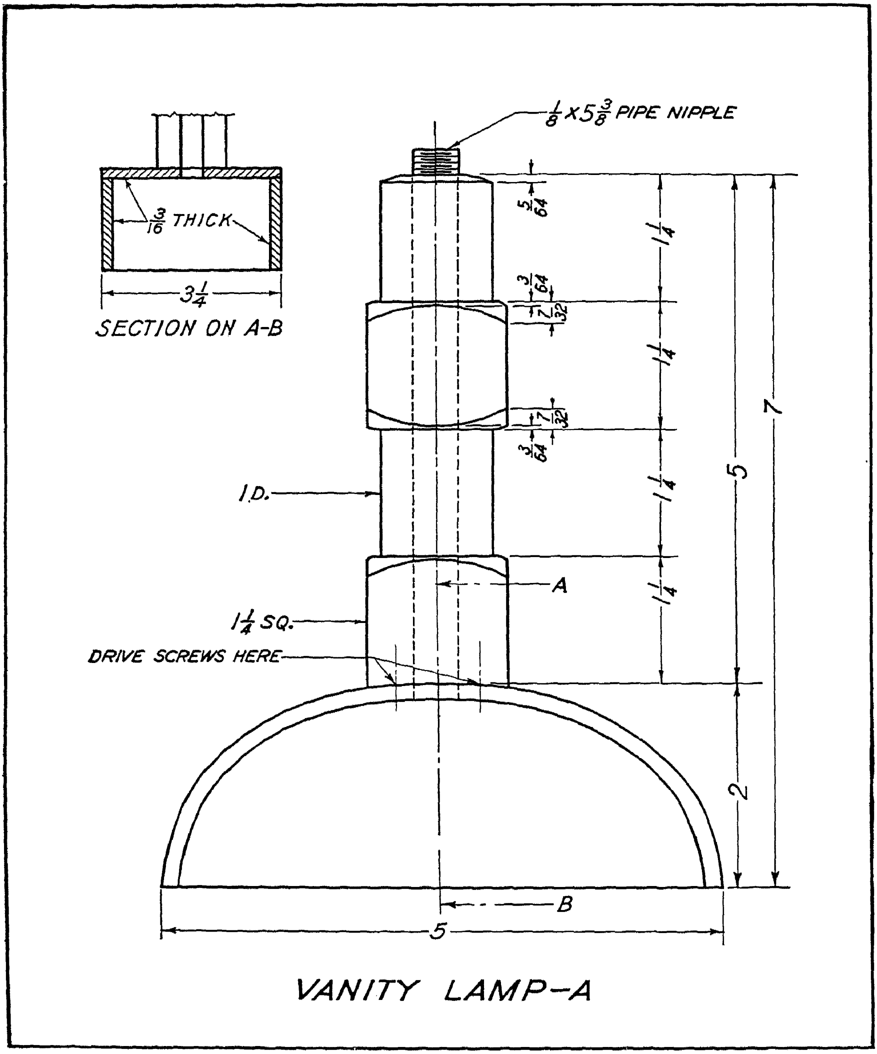
OCCASIONAL LAMP—B

This *occasional lamp* is made up of a combination of round rods and discs. All parts are cut from stock sizes of cast plastics. The small portion of chromium in the center of the lamp column adds an interesting variation from the plastics structure.

Time in construction may be saved if all four of the discs are marked out with dividers and cut to rough dimensions at the same time. All discs should be drilled *on center*. Perhaps the easiest method of mounting for turning is the use of a machine arbor fitted with a ⅛″ pipe nipple. A machine-screw arbor, however, may be used and the hole drilled for the pipe nipple just before final assembly. Since all of the discs, except the topmost one, have machine-screw holes in the same position, it is necessary to make the layout of the hole positions on only one. All three can be drilled at the same time if a short pipe nipple is screwed into the base to hold all three discs *on center*. All sanding and polishing operations should be completed on the lathe arbor after the turning operations are finished.

The four rods used for the lamp column should be cut to exact length and centered at both ends with a center drill. One end should be drilled and tapped for a machine screw to make an easy type lathe mounting. One end can then be supported by a machine-screw arbor and the other by the dead center. Sanding and polishing operations can be performed in this manner much easier than by hand. All parts should have a final buffing operation on a cloth wheel.

The parallel lamp cord is run up through the length of chromium tubing. Since the base rests flat on a table, a hole is drilled from the edge of the base to the pipe nipple. A side is cut out of the chromium tubing so that the lamp cord can pass up through the center of the lamp column. A bushing at the wire hole on the base edge is optional. A short length of ⅛″ pipe nipple should be fitted to the ⅜″ I.D. tubing so that a lamp receptacle may be screwed in place.



1/8 X 5 3/8 PIPE NIPPLE
3/16 THICK
3 1/4
SECTION ON A-B
5/64
3/64
7/32
1 1/4
7/32
3/64
1 1/4
1 1/4
1 1/4
5
7
2
I.D.
A
1 1/4 SQ.
DRIVE SCREWS HERE
B
5
VANITY LAMP—A

Plate 45

Plate No. 45

VANITY LAMP—A

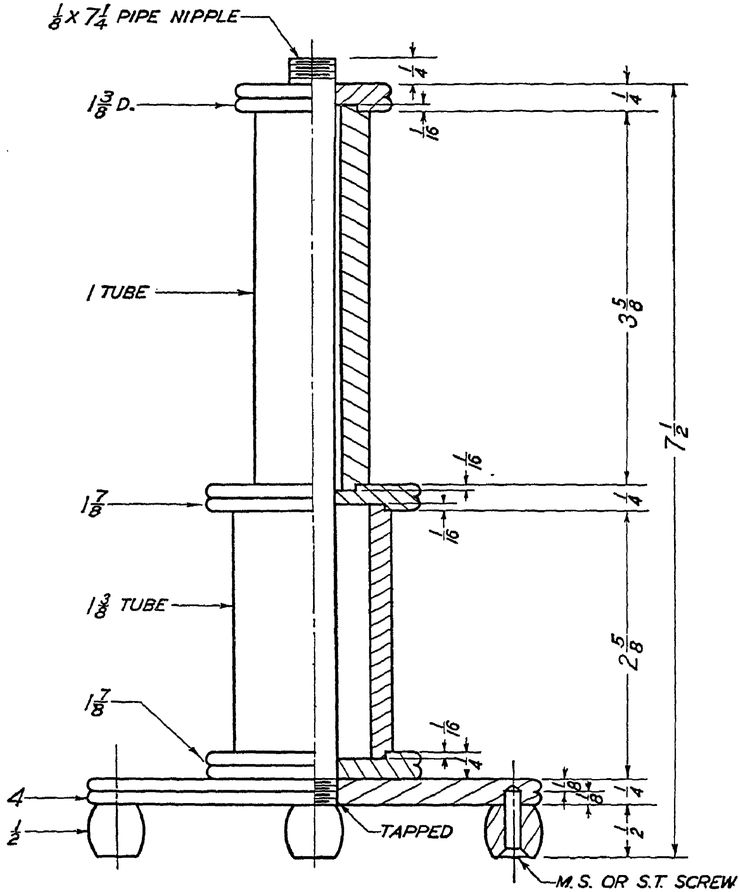
Cubes, cylinders, and irregular curves are combined in developing the design for this *vanity lamp*. Harsh corners at the top and bottom of the cubes are relieved by a chamfering operation while the cubes are turning on center. This operation provides an interesting curve which makes the transition from a cylinder to a cube less abrupt. In profile, the lamp base is one-half of an ellipse. Since a thin sheet of plastics is added on each side to fill in the profile, an appearance of stability is achieved.

Color variation is possible with the number of parts making up the lamp. A variation in the intensity of a given hue is recommended rather than the use of contrasting hues. The lamp base may match, in hue, either the cubes or the cylinders, but the former combination should prove more satisfactory. If base and lower cube match, the lower cube has an appearance of part of the lamp base.

Interesting bending and turning operations arise with this problem. Parts in the lamp post must be centered accurately or the chamfers will not be identical in size at all corners. Corners of the cubes must be turned at high speeds and with very thin cuts to prevent chipping of the plastics.

Bending of a sheet of plastics to the profile of the lamp base requires a bending form. The wood form must be accurately made and oiled to prevent sticking when cementing is done. Plastics sheets are cut with the same curvature as the bending form and placed at each side of the curved piece. The concave or outside portion of the bending form is used when the base parts are cemented together.

A hole $\frac{13}{32}''$ in diameter is drilled through the center of each post part. The pipe nipple will then hold all parts in position. A $\frac{21}{64}''$ hole in the base is tapped to make a lock nut at the lower end of the pipe nipple unnecessary. A proper curvature at the lower end of the lamp post is secured with a sanding drum. This post must fit the curvature of the base. Drive screws or self-tapping screws hold the lower cube to the base.



VANITY LAMP–B

Plate 46

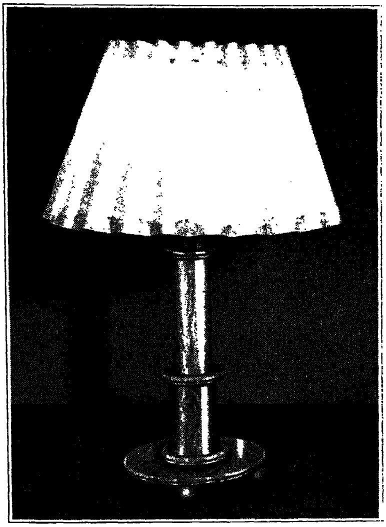


Figure 147. Vanity lamp.

Plate No. 46

VANITY LAMP—B

The turning operations for the *vanity lamp* are different from turned work shown heretofore. Grooves are turned in the small discs to fit tenons on the cylinder sections. Four discs and two sections of plastics cylinders make up the lamp body. A short section of ½″ D. rod is necessary for the four feet.

All discs are mounted for turning on a $\frac{5}{16}$″ arbor. The grooves may be turned with this type of mounting, or they may be held in a universal chuck. Cylinder sections may either be held in a lathe chuck or be supported on a mandrel for turning. Feet parts are mounted on a machine-screw arbor. All parts of the lamp are held together by a pipe nipple.

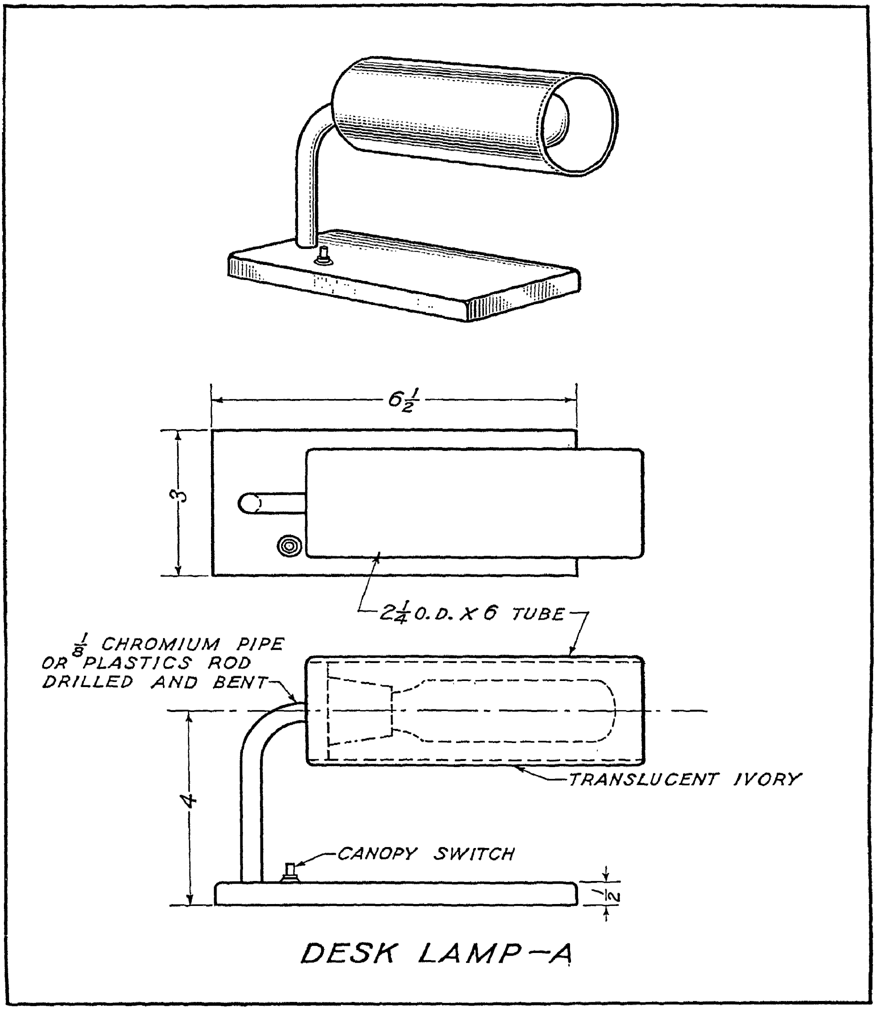

6 1/2
3
2 1/4 O.D. X 6 TUBE
1/8 CHROMIUM PIPE
OR PLASTICS ROD
DRILLED AND BENT
TRANSLUCENT IVORY
4
CANOPY SWITCH
1/2
DESK LAMP—A

Plate 47

Plate No. 47

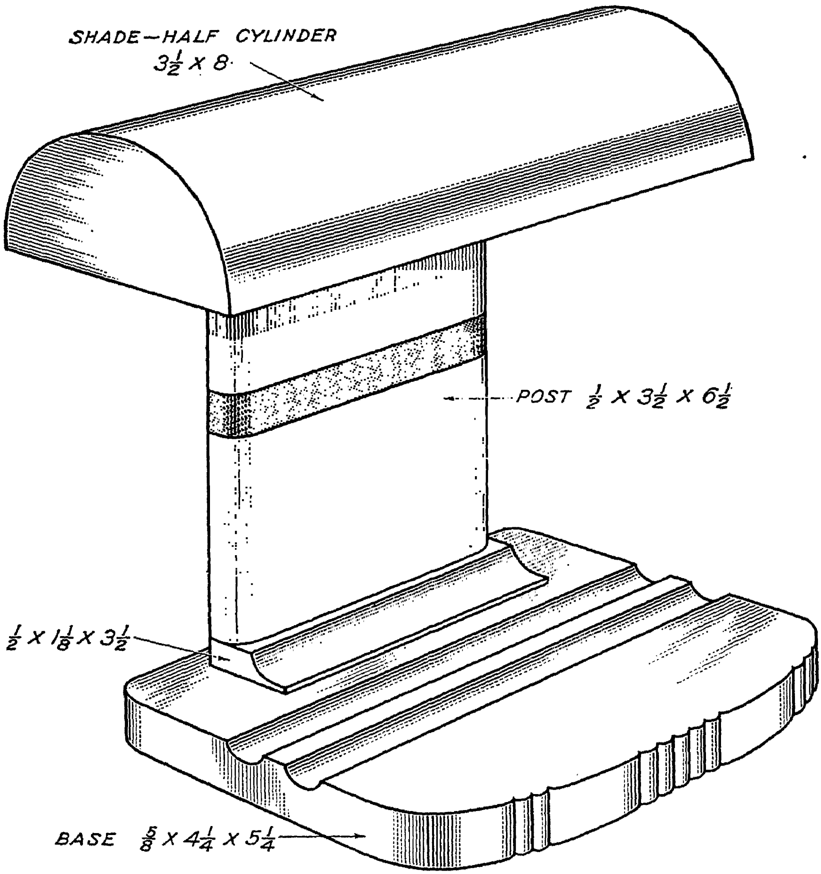
DESK LAMP—A

There have been constant demands for lighting devices which produce non-glare light over one's desk or in similar places. A translucent plastics type is the diffusing agent employed in this desk lamp. A softened light is possible and, at the same time, a colored effect of a wide range may be effected on the light.

The lamp post or wiring column may be made from a length of $\frac{1}{8}''$ chromium-plated pipe or from a length of plastics rod. When chromium-plated, brass pipe is used, it should be filled with packed sand and bent around a bending form adapted to the pipe size. Both ends of the pipe are threaded so that the column will support the tube. If a plastics rod is to be used, a $\frac{5}{8}''$ D. rod should be drilled to accommodate parallel lamp cord. The ends should be threaded with a $\frac{5}{8}''$ die. When bending the plastics, heat should be applied in liquid form (see Chapter 5) until the full tube is flexible. A bending form to fit the rod diameter should be constructed.

A section of $2\frac{1}{4}''$ O.D. tube is secured for mounting the incandescent lamp. A disc is turned to fill one end so that a receptacle may be supported and so that the bent rod can support the tube. A receptacle may be mounted on this disc with machine or self-tapping screws. The mounting and all necessary provisions for the lamp cord should be made, however, before the disc is cemented in place. A buffing rod should also be used on the interior of the tube before the disc is cemented in place. The surface should be smooth so that a maximum amount of light can pass through. Tapping the disc to proper size may be done either before or after cementing.

Shaping of the lamp base is quite simple since it consists merely of squaring a rectangle of plastics to dimensions, surfacing and buffing the same. A hole is drilled and tapped for the lamp post and another hole is drilled for the canopy switch. Wire should pass through the base from the rear. The necessary paths for the wire should be routed in the base. When the lamp is assembled and the wiring completed, bare wires may be insulated with sealing wax.



DESK LAMP—B

Plate 48

Plate No. 48

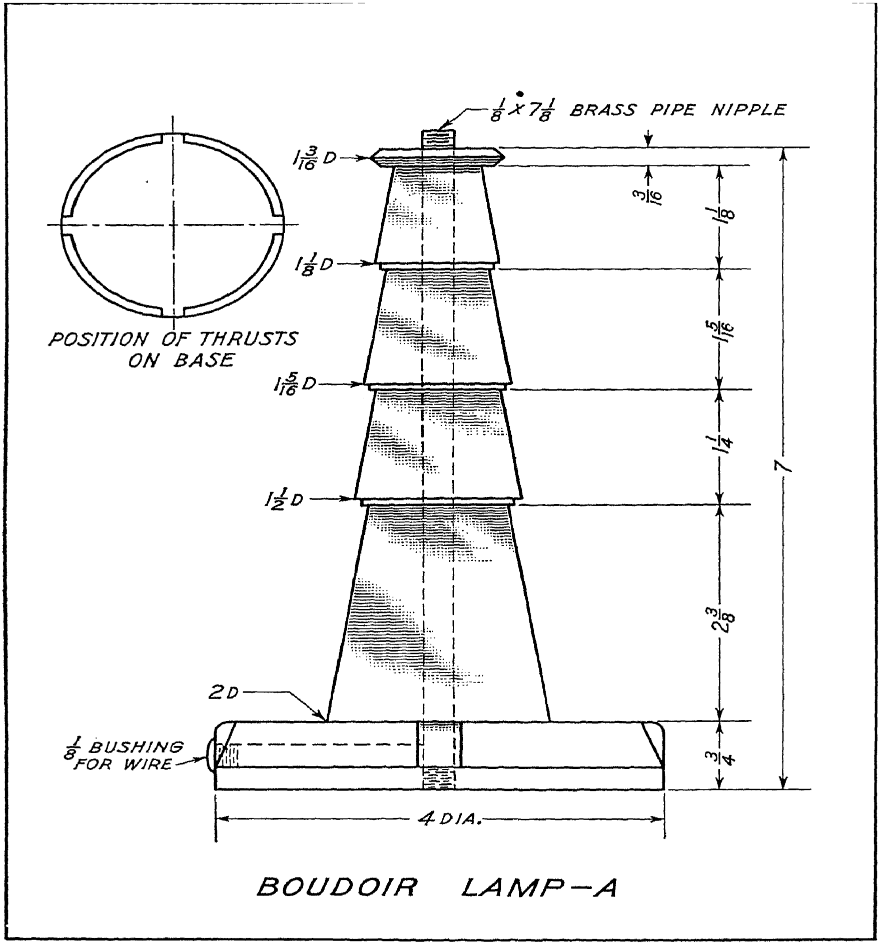
DESK LAMP—B

The design for this *desk lamp* originates with the ideas of utilizing a section of a plastics tube for the light shade and, at the same time, making use of the lamp base as a desk tray. A rectangular post, therefore, lends itself to this type of design.

Perhaps the shade should be the first part of the lamp to be constructed. A $3\frac{1}{2}''$ O.D. or slightly larger cylinder is cut in half and the ends filled up with semi-circles of $\frac{1}{2}''$ thick plastics of the same color. A light receptacle is fastened to one end with self-tapping screws. After the semi-circles are cemented in place, the ends of the cylinder section are sanded square on a disc sander. The inside of the cylinder should be smoothed and polished before the ends are filled.

A rectangular slab of plastics is shaped so that the edges are a semi-circular shape in cross-section. The top end of the post is rabbeted and fitted to the curvature of the shade. The rear of the post is flush with the rear of the shade when the lamp is finished. A piece of plastics is fitted to lap over both post and shade at the joint so that it may be strengthened. A band of thin inlay is added to the post. The post base is shaped from a piece of $\frac{1}{2}''$ plastics sheet. Smoothing of the cone is accomplished by using abrasive paper held over a dowel or other rod.

The lamp base is shaped from a section of $\frac{5}{8}''$ plastics sheet. Beads laid out at the front edges are filed to shape on a jig saw or with a hand file. The pencil grooves are shaped with an engraving tool made from a flat file and are sanded with abrasive paper held over a dowel. Two machine screws hold the base and post parts together. The parallel lamp cord enters the base from the rear edge and runs up through one edge of the post and over to the receptacle in the shade. Necessary grooves are routed in the base so that a canopy switch can be installed at the right edge of the lamp post. When all parts are buffed, they should be assembled with machine screws and cement. A wiring operation is the last step in construction.



1/8 X 7 1/8 BRASS PIPE NIPPLE
1 3/16 D
3/16
1/8
1 1/8 D
1 5/16
1 5/16 D
1 1/4
7
1 1/2 D
2 3/8
2 D
1/8 BUSHING FOR WIRE
3/4
4 DIA.
POSITION OF THRUSTS ON BASE
BOUDOIR LAMP—A

Plate 49

Plate No. 49

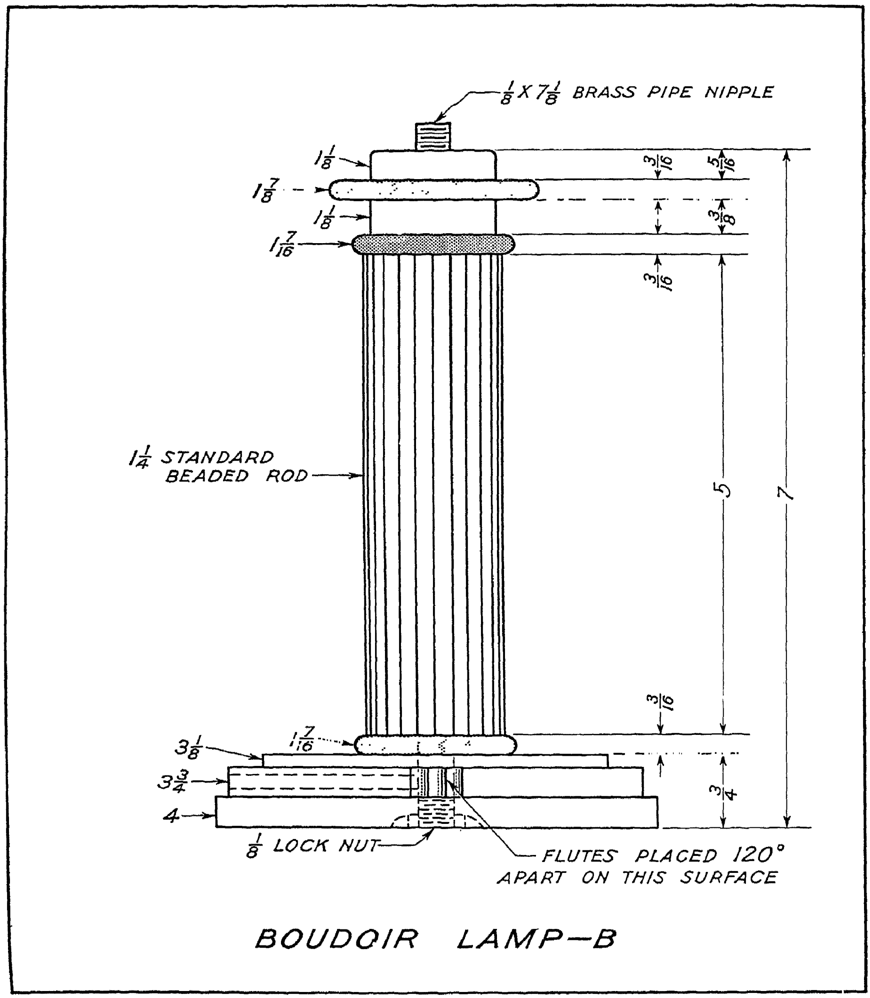
BOUDOIR LAMP—A

The cone is the geometric shape which forms the basis for the design of this *boudoir lamp.* A series of four cones is combined in the post and the base shape is a variation of a cone. The very nature of the design form permits many combinations of color and permits the use of several small pieces of plastics. On the other hand, only two pieces of plastics having the same hue are necessary.

The lamp post may be turned from a single length of 2″ D. plastics rod or it may be turned from four sections of rods and one disc. If a single length is used, it will be necessary to support the live center end with a machine-screw arbor and the other end with the dead center. When the post is turned in sections, support by an arbor is all that is necessary for both horizontal and cross turning. Extreme care in turning should be taken so that all of the offsets at the base of each of the three top, cone sections will be of uniform shape.

Four thrust pieces on the lamp base may be shaped from a turned base disc or may be shaped from separate pieces of castings and cemented in place. In either procedure, the base can best be turned while mounted on an arbor. Perhaps a more accurately shaped base may be secured if the thrust pieces are cemented on after the top part of the base has been chamfered. All thrust pieces should be left slightly over-size so that a thin cut can be taken from the base edge and top to even up all joints.

The lamp parts may be held together by a pipe nipple as shown on Plate 49 if the base is tapped. If made in one piece the top end of the post may be tapped and a short length of pipe nipple inserted to hold the receptacle. In the latter case machine screws will hold the base and post together. Wiring details are shown on the plate.



$\frac{1}{8}$ X $7\frac{1}{8}$ BRASS PIPE NIPPLE
$1\frac{1}{8}$
$1\frac{7}{8}$
$1\frac{1}{8}$
$1\frac{7}{16}$
$\frac{3}{16}$
$\frac{5}{16}$
$\frac{3}{8}$
$\frac{3}{16}$
$1\frac{1}{4}$ STANDARD BEADED ROD
5
7
$\frac{3}{16}$
$1\frac{7}{16}$
$3\frac{1}{8}$
$3\frac{3}{4}$
4
$\frac{3}{4}$
$\frac{1}{8}$ LOCK NUT
FLUTES PLACED 120° APART ON THIS SURFACE
BOUDOIR LAMP—B

Plate 50

Plate No. 50

BOUDOIR LAMP—B

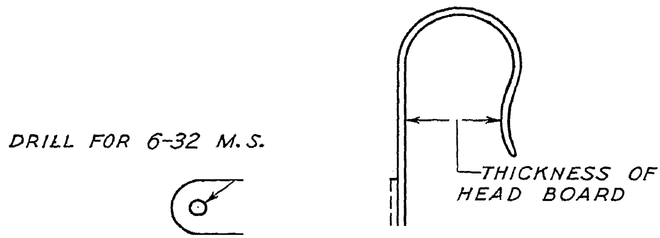
This *boudoir lamp* has been designed from standard castings. A beaded rod forms the center of the design. The same shape is carried through all disc edges. Vertical lines from the beads provide the vertical thrust and tend to add height to the lamp column. At the same time, the horizontal discs provide horizontal thrusts for variety. Flutes in the base carry the column shape in reverse and, at the same time, add variety to an otherwise monotonous base.

A section of $1\frac{1}{4}''$ D. beaded rod $6''$ long is necessary for the lamp column. Two short lengths of this rod at the top are produced by turning off the beads to a solid circle. These three parts from the beaded rod may be turned while the rod is held between centers or the top sections may be cut off and turned while mounted on an arbor.

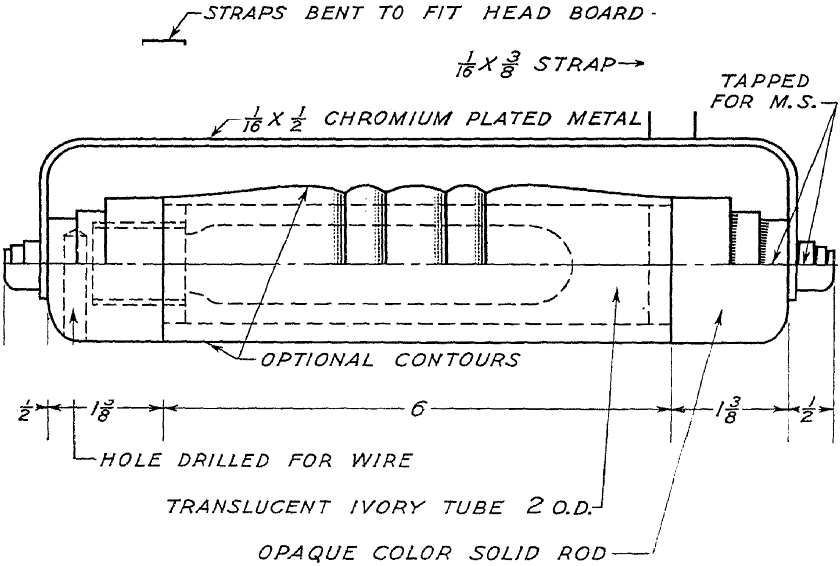
Three discs are cut from a $\frac{3}{16}''$ sheet of plastics and turned to size and shape while held on an arbor. A color variation should be evident in these discs. Complementary hues or hues near that of the beaded rod should be adhered to.

The lamp base is made from three parts. Both top and bottom sections are plain discs of the diameter shown. The middle section is turned from a $\frac{1}{4}''$ sheet. Three sets of three flutes are laid out on center lines 120 degrees apart. The flutes are filed to shape on a jig saw. Fine abrasive paper may be wrapped around the file for smoothing the flutes.

It is necessary to drill a $\frac{13}{32}''$ D. hole through the center of all parts to permit a pipe nipple to pass through. The bottom of the lower base disc is counterbored to provide for a $\frac{1}{8}''$ lock nut. A hole is drilled from the base edge to the center hole and through the pipe nipple to permit parallel lamp cord to pass through.



DETAIL OF SUPPORT STRAPS



BED LAMP

Plate 51

Plate No. 51

BED LAMP

The *bed lamp* is designed to be placed over a bed headboard. Since there is no uniformity in headboard design, there can be no uniformity in design for support straps. One common style which will prove satisfactory is suggested. A translucent plastics tube diffuses the light sufficiently to produce a soft illumination.

Two short lengths of 2″ D. rod are necessary for the ends of the bed lamp. These are mounted on an arbor and turned with a shoulder to fit the inside tube diameter. When both end pieces are turned and the tube ends squared, the three pieces are mounted in a lathe between centers, between a chuck and center, or between an arbor and a center. All three parts should be turned at one time so that the two joints will be least noticeable. Two contour shapes are suggested. A tiny reference line should be made at each joint before the parts are disassembled so that they can be reassembled in the same position when necessary.

Two knobs or nuts should be turned for the lamp ends. Short lengths of a machine screw should be fitted into the inside of each knob so that the support straps can be held in place. Holes for the machine screws are drilled and tapped in each tube end piece.

The electric wiring on this lamp presents some little difficulty because of close quarters inside of the tube. An old lamp receptacle is torn apart and the two contacts for an incandescent lamp retained. One tube end support is recessed for the socket. Holes are drilled for the electric wire which is connected to the contact points of the receptacle. Since plastics is an insulator, bare wires may be run through small holes. A switch may be installed *in* the lamp or *on* the lamp cord.

Three pieces of metal which may be fastened together with machine screws or welding, are required for the support straps. The metal should be chromium plated or polished. Felt strips may be cemented to that portion of the straps which contacts a finished surface.

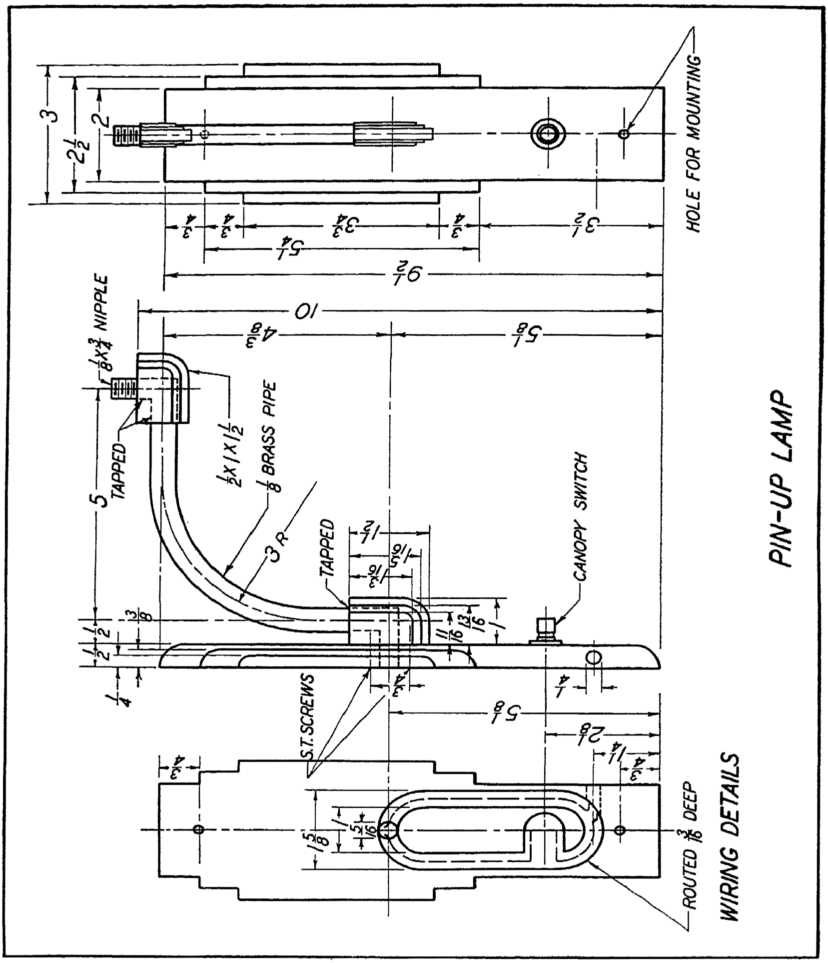

PIN-UP LAMP
WIRING DETAILS
HOLE FOR MOUNTING
CANOPY SWITCH
TAPPED
TAPPED
S.T. SCREWS
ROUTED 3/16 DEEP
1/8 X 3/4 NIPPLE
1/2 X 1 X 1 1/2
1/8 BRASS PIPE
3 R

Plate 52

Figure 148. Pin-up lamp.

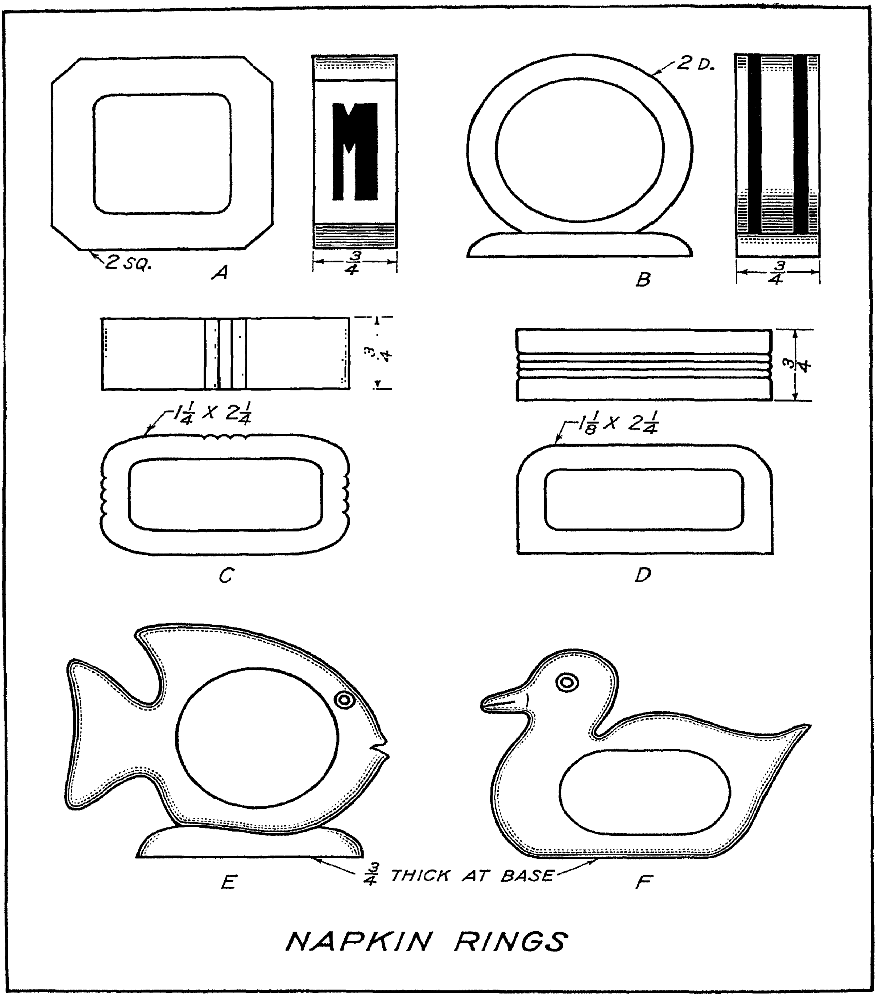
Plate No. 52

PIN-UP LAMP

This lamp makes an attractive reading lamp for a den or bedroom. A molded plastics diffusing reflector placed under a shade adds height to the lamp and produces light of more pleasing quality.

If a shaper or router is available, the design at the edges of the lamp body and of the little support blocks is easily made. If this shaping must be done by hand, strips of thin material may be cut and cemented to the body pieces. A router should be used on the back of the lamp body.

A section of brass pipe is threaded, filled with packed sand, and bent to the required arc. If there is a tendency for the pipe to turn in the plastic blocks at each end, a self-tapping screw should be inserted from an unexposed point. A parallel lamp cord enters the side of the lamp body. A canopy switch is used to control the light.



2 SQ.
A
3/4
2 D.
B
3/4
3/4
3/4
1 1/4 X 2 1/4
C
1 1/8 X 2 1/4
D
E
3/4 THICK AT BASE
F
NAPKIN RINGS

Plate 53

Plate No. 53

NAPKIN RINGS

There are several designs for napkin rings suggested on Plate 53. Some of the designs originate from standard tube cross-sections and others are cut from plastics sheets. Four designs require machine work, for the most part, and two designs require practically all hand work.

Napkin ring *A* is made from a section cut from a standard tube casting. A metal initial or cellulose sheet initial is cemented to one edge for identification. Napkin ring *B* is made from a section of a 2″ O.D. tube mounted on a flat base. Some type of surface treatment is added to the ring. This may be an inlay, an overlay, or merely a groove. Cuts are made when the ring is mounted on a lathe mandrel (see Figure 76). A section of the ring is flattened and it is cemented to a base.

Napkin rings *C* and *D* are cut from a $\frac{3}{4}''$ thick sheet. The holes are cut out on a jig saw. Beads on *C* may be filed to shape with a jig saw. The horizontal lines on *D* may be cut with a shaper. The three beads extend over the top and down both ends.

Napkin rings *E* and *F* must be shaped by hand. The outline is sawed out of a $\frac{3}{4}''$ sheet of plastics on a jig saw. As soon as the napkin hole is sawed out, shaping with a hand file begins. Bases on both designs should be left nearly full width. Rough cutting along the arrises may be done with a bastard metal file or with a wood file. Finer files are used for the final cuts. A graver or small file ground for the purpose, is used to shape that portion of *E* which joins the base. A graver may be used to shape eyes on these two rings. Drive screws may be installed to give the appearance of eyes.

Successively fine grades of abrasive papers should be used to remove all file and graver marks. A highly buffed surface should be produced on all napkin rings.

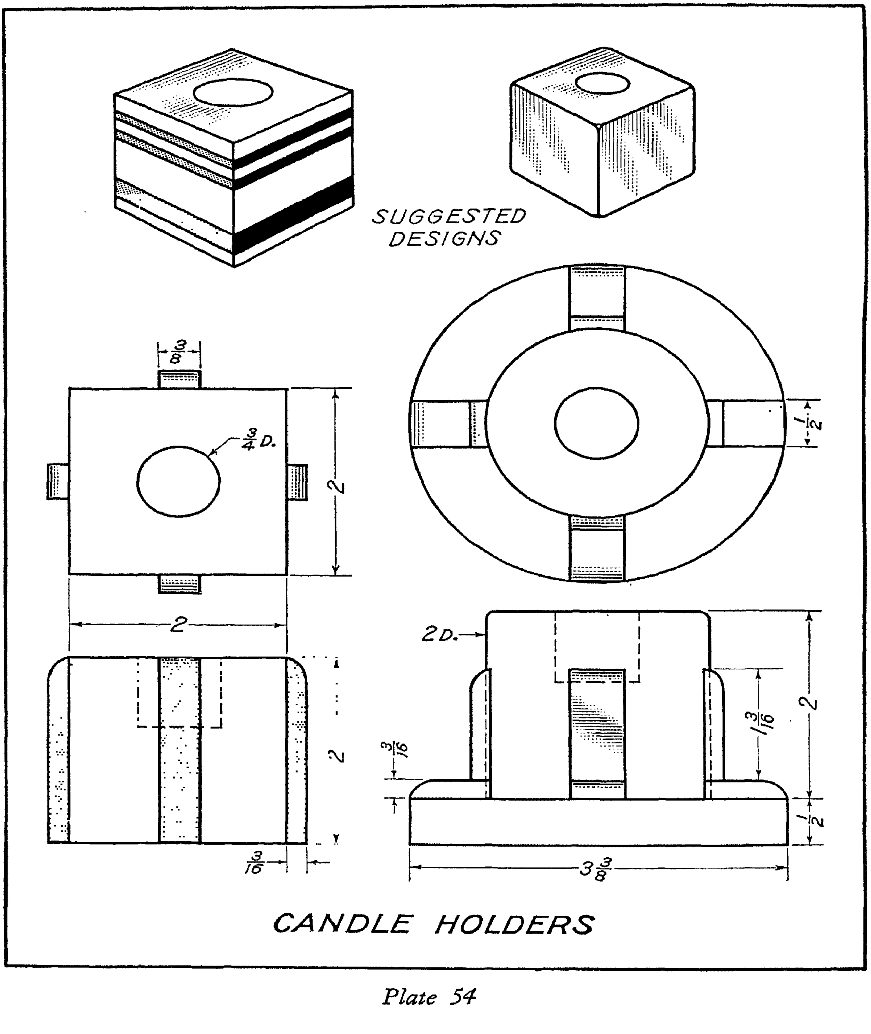

SUGGESTED DESIGNS
3/8
3/4 D.
2
2
2
3/16
1/2
2 D.
1 3/16
2
3/16
1/2
3 3/8
CANDLE HOLDERS

Plate 54

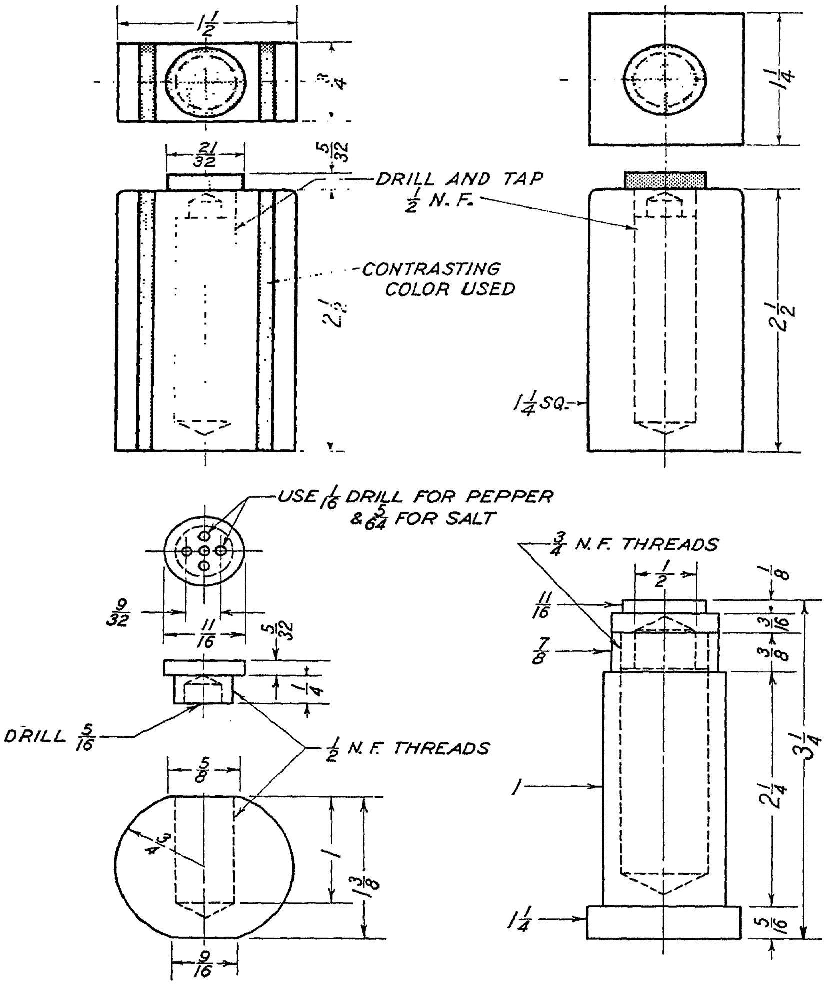
Plate No. 54

CANDLE HOLDERS

There are just two demands which are placed upon every candle holder: there must be a hole into which the base of a candle may be thrust and the holder must have sufficient weight to hold the candle in an upright position. From these points on, there are many factors which influence the type of material which is to be used as well as the shape which it is to take in its finished form. If the surroundings demand an antique appearance, perhaps metal is the best structural material. A buffet of walnut or mahogany with a lot of turning on the legs should be graced with a turned candlestick of figured cabinet wood. If, on the other hand, there is a buffet of modern design and waterfall edges, a ceramics or plastics candle holder is more appropriate.

Design for the *candle holders* on Plate 54 starts with one of two simple geometric shapes, a cube or a cylinder. The suggested designs and the dimensioned candle holder, at the left side of Plate 54, are planned for short wax candles. The cube may be given variety by one of the following methods: (1) bands of inlay or overlay in a different hue added on all sides, (2) bands of a different surface texture, such as a sanded or etched effect, added after all color buffing is done, (3) the exterior surfaces of transparent plastics color buffed until all minute scratches are removed, and (4) thrust pieces added on all vertical sides.

The lower right-hand design places a cylinder upon a $\frac{1}{2}'' \times 3\frac{3}{8}''$ D. disc. Thrust pieces placed at 90-degree intervals are run from the edge of the disc to the cylinder. On top of the horizontal thrust pieces are the same number of vertical thrust pieces extending approximately five-eights of the height of the cylinder. The base and cylinder should be fastened together with machine screws to insure accurate centering. All other parts are cemented in place.



SALT & PEPPER SETS

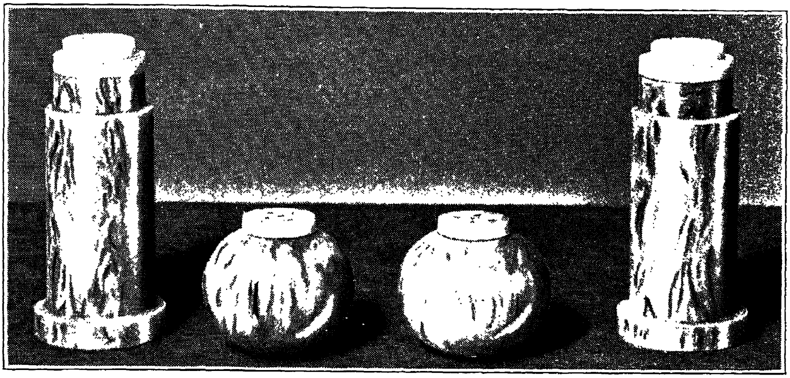


Figure 149. Salt and pepper sets.

Plate No. 55

SALT AND PEPPER SETS

Four designs for *salt and pepper sets* are included on this plate. Two of the designs, only, require lathe operations on the shaker bodies. Both of the shaker bodies shown at the top of Plate 55 are made from standard castings. A square rod is used for the design at the right. The laminated shaker requires four thin sheets and a rectangle cut from a $\frac{3}{4}''$ sheet. Each of the sets is designed with screw caps so that the shakers can be filled from the top.

Operations including: threading the cap, drilling the center hole, and tapping for the cap thread, are a bit difficult. Matched arbors (Figure 74) have been used successfully for holding the plastics parts for turning. The hole diameter on the inside of each shaker is limited to the tap-drill size for the desired thread. Each cap is recessed so that thickness at the holes is decreased. This permits the condiment to leave the shaker more readily and provides greater capacity.

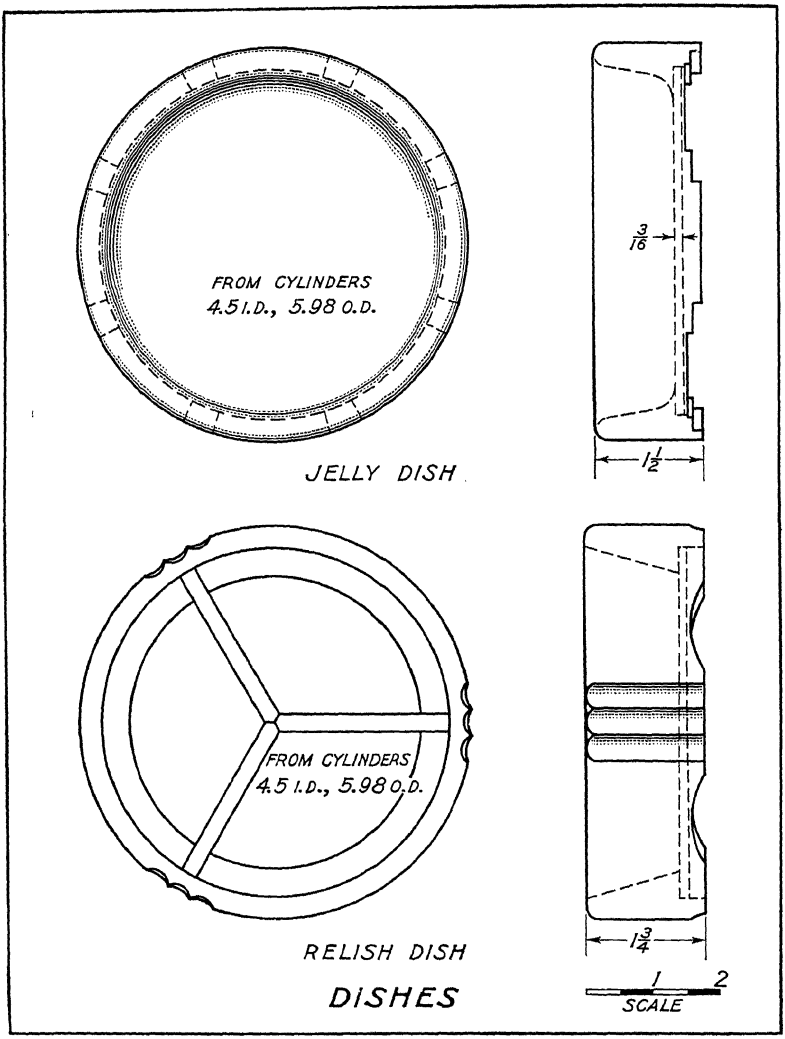

FROM CYLINDERS
4.5 I.D., 5.98 O.D.
3/16
1 1/2
JELLY DISH
FROM CYLINDERS
4.5 I.D., 5.98 O.D.
1 3/4
RELISH DISH
DISHES
1 2
SCALE

Plate 56

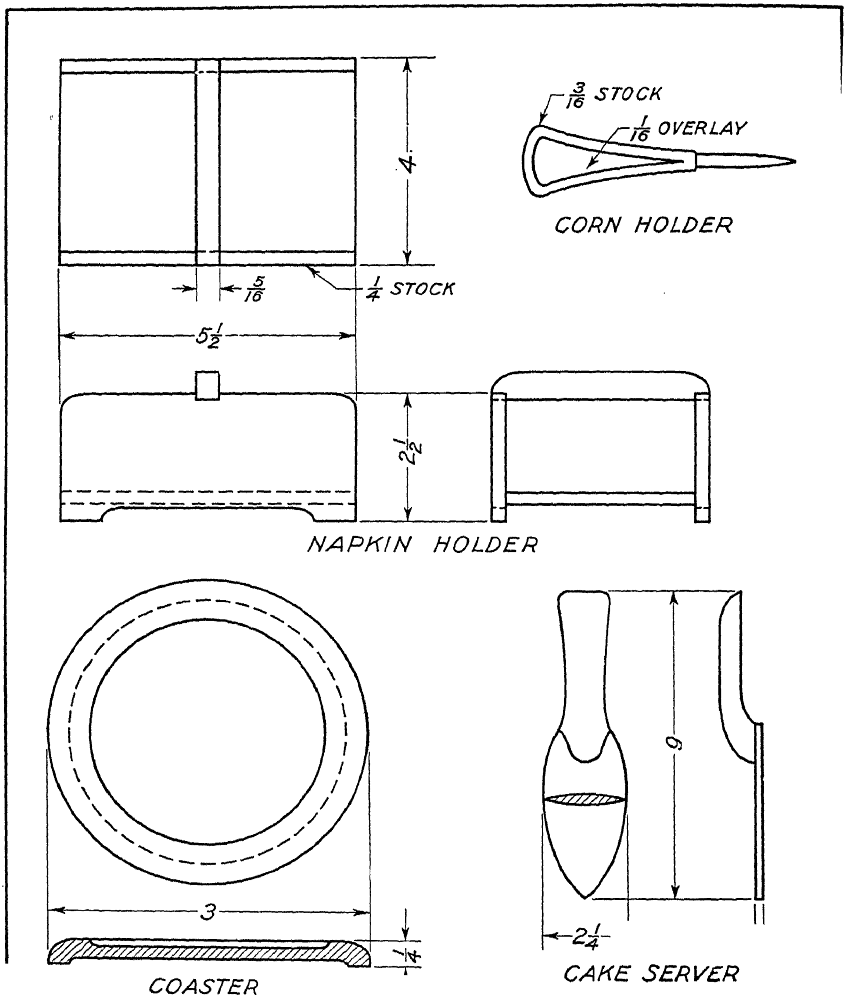
Plate No. 56

DISHES

Cast resinoids give off no odors and do not absorb odors from foreign materials with which they come in contact. Moisture absorption of the plastics materials is negligible. For these reasons, cast and molded plastics have been used commercially for fabricating food containers and other articles which come in direct contact with foods. All surfaces may be buffed to a very smooth finish. Since particles of food will not cling to the finished surface, plastics are sanitary.

Jelly containers require very low sides and flat bottoms. The *jelly dish* is made from a short length of plastics cylinder. With the ring mounted in a lathe chuck, a rabbet is turned on the bottom edge. A $\frac{3}{16}''$ sheet is cemented in place for the bottom of the dish. When the dish can be reversed in the lathe chuck, the inside and top edge is turned to shape. All ashing and polishing operations are performed before the dish is removed from the lathe for the balance of its shaping. A base design similar to that shown on Plate 56 is laid out and cut to shape with saws and files. Dimensions are purposely omitted from the plate in order that individual designs may be developed. This jelly dish has four feet placed at 90-degree intervals.

Requirements for relish dishes vary from those of a jelly dish. Usually two or more kinds of relish are served and a partitioned dish is required. The *relish dish* on Plate 56 is made from a section of the same plastics cylinder already mentioned. A bottom is installed and the inside is shaped in the manner indicated. When these operations have been completed, three thin partitions are fitted as shown and cemented in place. Three groups of flutes are shaped at 120-degree intervals on the outside of the dish. Between each pair of these flutes at the bottom edge of the dish, a decorative shape is added to relieve monotony.



TABLEWARE—A

Plate 57

Plate No. 57

TABLEWARE—A

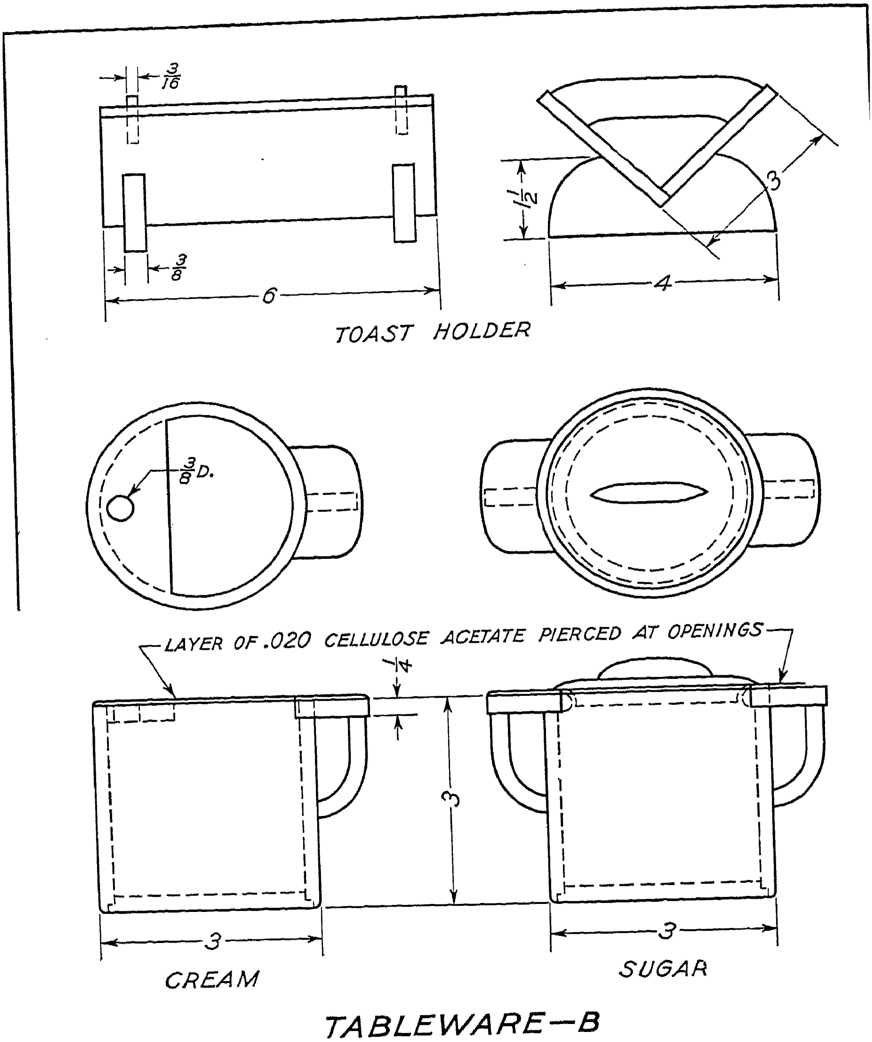
The era of gold-banded tableware and large floral decorations on dinner sets is passing into history. Variety and color in table decorations are being achieved in a different manner. The monotony of plainer colored and designed dinner sets of the present is relieved by sparkling glassware and colorful table accessories (see Plate 18). An abundance of color is possible with the table accessories shown on Plate 57.

Corn holders are designed for individual use in pairs to assist in keeping one's fingers clean when corn is served on the cob. Dimensions on the problem are purposely omitted.

A *napkin holder* for paper or linen napkins has a very definite place when teas or buffet luncheons are served. All of the parts of this problem may be fastened together with cement. Small metal dowels must be installed in the joint between each side and the bottom to insure accurate placement of the parts until the cement has set. These dowels are not to be left exposed. Obviously a good cemented joint should be obtained at both ends of the handle.

Coasters in pastel colors should make delicate glassware stand out among other table decorations. At the same time, they will prevent condensed moisture from ice-drink containers running over a table covering. This problem is turned while held in a three-jaw lathe chuck. A disc of wood or other material, which has been turned for the purpose, should be placed in the lathe chuck just behind the coaster disc so that it can be reversed in the chuck quickly and accurately.

An inexpensive *cake server* can be made from two pieces of plastics. Rough cutting and filing to shape is done before the parts are cemented together, but the final shaping and all buffing should wait until after the cake server has been assembled.



3/16
3/8
6
1 1/2
3
4
TOAST HOLDER
3/8 D.
LAYER OF .020 CELLULOSE ACETATE PIERCED AT OPENINGS
1/4
3
3
3
CREAM
SUGAR
TABLEWARE—B

Plate 58

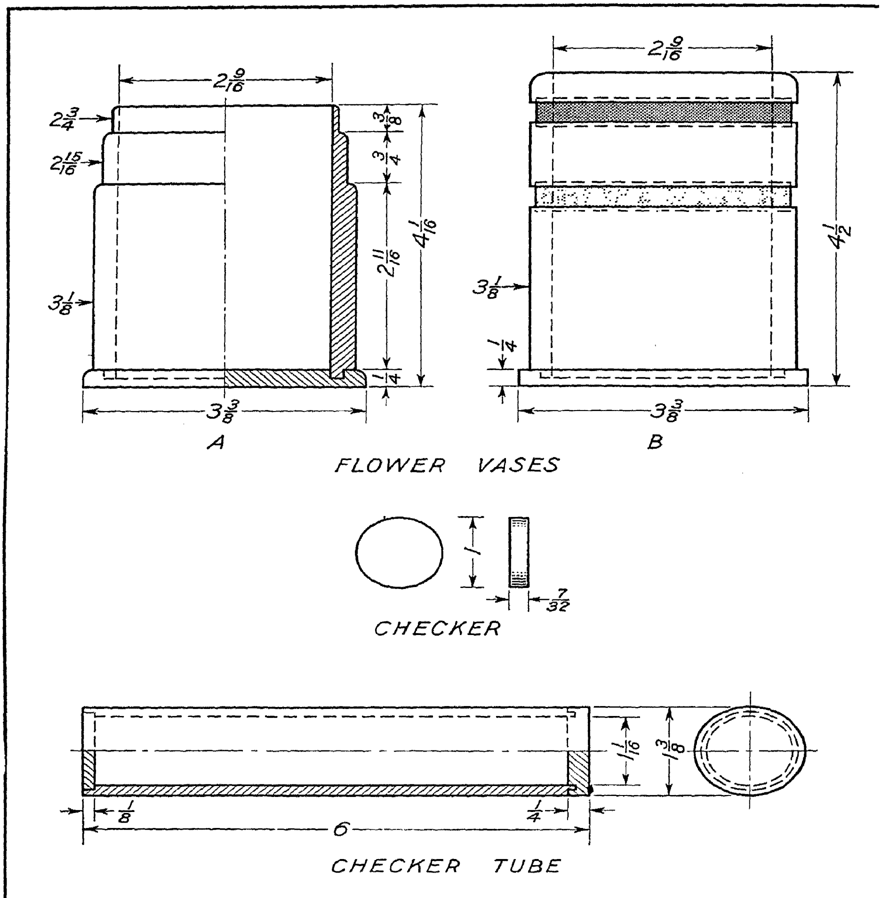
Plate No. 58

TABLEWARE—B

Problems shown on Plate 58 are somewhat more difficult to construct than those on the preceding plate. Plates showing simple and complicated problems are presented to suggest a range of possibilities for plastics in the construction of table accessories. Elaborate units such as a centerpiece and candle holders to match, a centerpiece and candelabra, a sugar and cream set, a set of supplementary dishes, and an iced tea set, fall within one's imagination.

A *toast holder* is a unit for one's breakfast table. Construction on this problem is comparatively easy even though the assembly of parts involves some care. Metal dowels are recommended for use in holding the parts in place until the cement has set.

A *cream and sugar* set is made of parts cut from standard castings and from thin acetate sheets (cellulose nitrate cannot be used in contact with foods because of its odor). Two cylindrical cups are shaped the same to a certain point. Three handles are cut to shape and as many handle caps are cut to size and fitted over the curved handles and to the curvature of the cup sides. When the handles are cemented in place, thin sheets may be placed over the entire top of each problem. These serve a dual purpose: that of adding a new color and that of strengthening the joints between handles and cup. This layer is pierced at the openings and trimmed back even with the casting. A thicker piece of cast plastics is placed under the pouring edge of the creamer. A hole is drilled to pour cream through. This hole may be chamfered at the top to form a basin for liquid which would otherwise drip over the edge. A cover for the sugar container is shaped as shown. The small handle is held in place with two drive screws.



VASES, CHECKER AND CHECKER TUBE

Plate 59

Figure 150. Flower vase, checkers, and checker tube.

Plate No. 59

VASES, CHECKER, AND CHECKER TUBE

Vases turned from a cylinder of plastics and with a base fitted and cemented in place in the manner indicated, should be waterproof. Design is somewhat limited by the size and shape of standard plastics castings. Bands of inlay from metal or thin sheet plastics make possible many variations in design.

Checkers of the size indicated should be carefully cut to thickness from a 1″ D. rod in a miter box or on a power cutting wheel. The rough discs are placed in a holder (similar to that in Figure 81), sanded, and buffed. When several discs are sanded at one time, there is less tendency to produce one edge thinner than the opposite edge. Twelve checkers each of two colors are necessary. A $1\frac{3}{8}$″ O.D. cast cylinder for the *checker tube* is just long enough to hold all twenty-four checkers. The cylinder is large enough at one end to let a checker slide in, but it tapers toward the opposite end. This makes it necesssary, therefore, to ream or bore the tube $1\frac{1}{16}$″ in diameter.

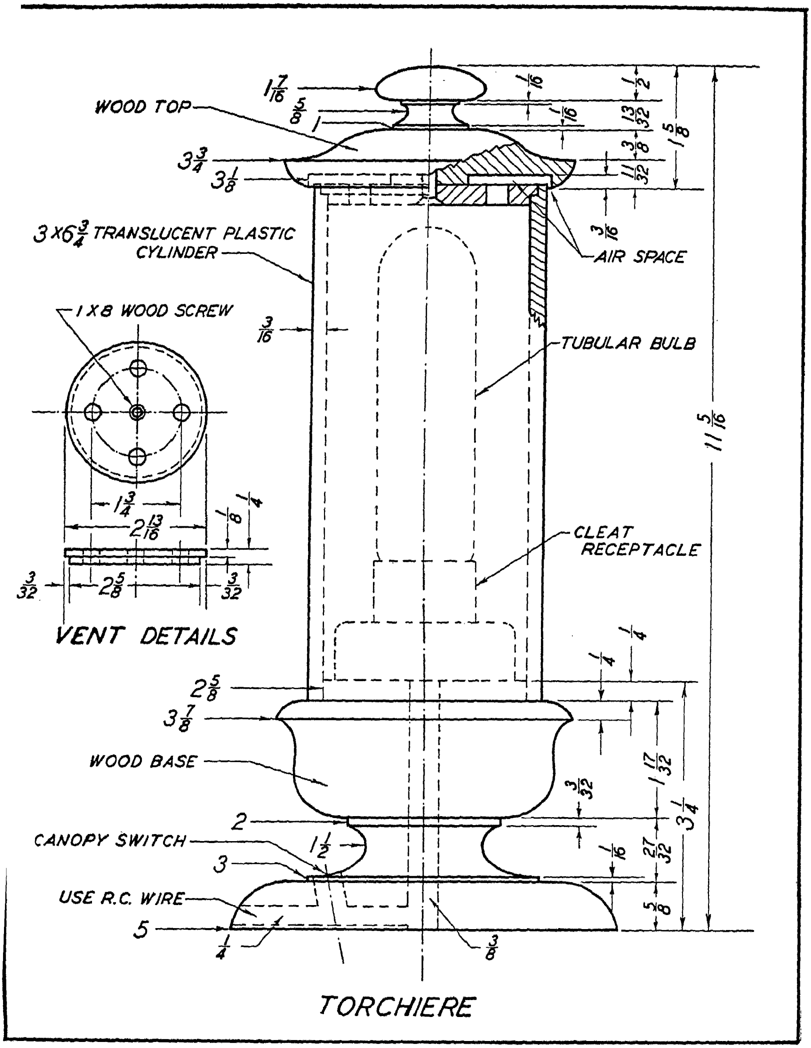

WOOD TOP
3 X 6 3/4 TRANSLUCENT PLASTIC CYLINDER
1 X 8 WOOD SCREW
AIR SPACE
TUBULAR BULB
CLEAT RECEPTACLE
VENT DETAILS
WOOD BASE
CANOPY SWITCH
USE R.C. WIRE
TORCHIERE

Plate 60

Plate No. 60

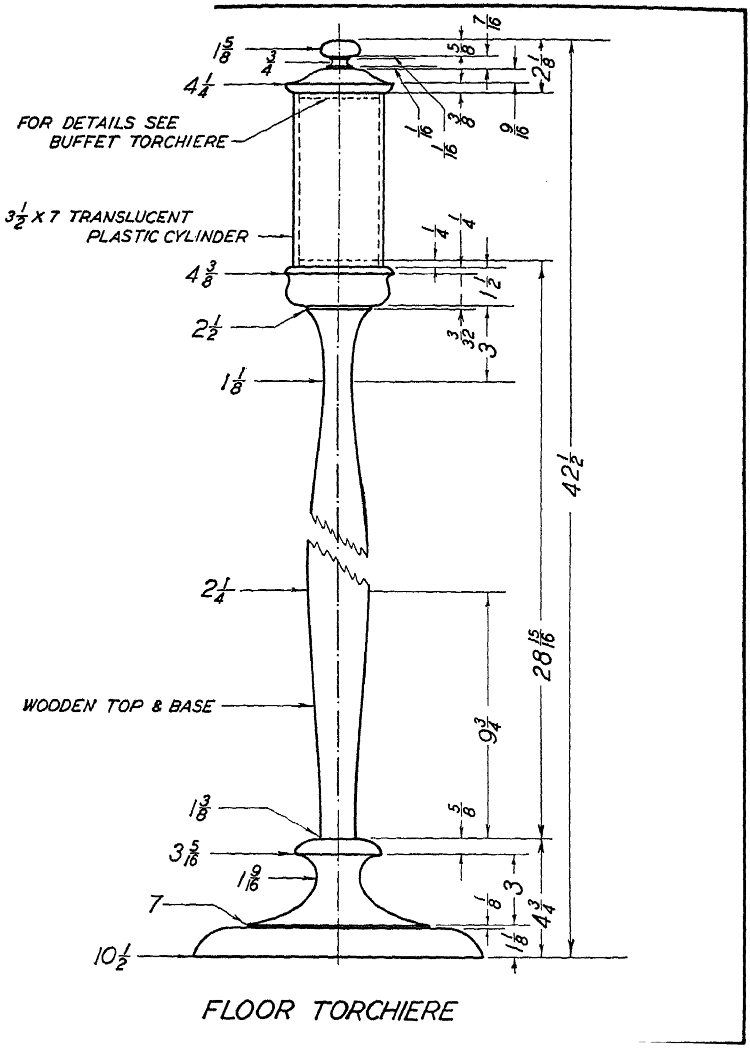
TORCHIERE

An attractive combination of wood and plastics is presented in the form of a *torchiere*. Native cabinet wood, such as black walnut, and a mottled, translucent, cast phenolic cylinder are royal representatives of their own types of materials.

Wooden parts of the torchiere present a problem of mounting for turning which is a bit out of the ordinary. It is suggested that sufficient stock be glued up so that the grain runs in a vertical direction on both top and base. The stock should be of a length sufficient to turn both of the pieces. It may be mounted on a face plate and the top turned first. When rough turning to a cylinder, a dead center may be used. The air vent groove should be turned first from the dead center end of the lathe. Cutting the top off is then done at the knob end. All sanding should be completed before the parts are separated. The base of the torchiere is a simple problem in face-plate turning. All curves on the design should originate with tangents, either parallel to or perpendicular to the lathe bed. Irregular curves are recommended. The supplementary disc fastened to the top can be turned by mounting on an arbor (see Figure 72).

A 3″ O.D. translucent plastics cylinder is necessary for diffusing light and for giving a pleasing size to the torchiere. Mount the cylinder on a mandrel (see Figure 75) for ease in turning ends square and for turning the rabbet on the top end. All sanding and ashing operations may be performed while the cylinder is thus mounted. Rotten stone on a damp cloth is sufficient to take the place of first buffing operations. Color buffing can be done while the cylinder is held against a cloth wheel.

Turning of wood and plastics should be accurately done so that *friction fits* will result. A safer light in use is thereby provided. Wiring details should provide no unusual difficulties. Care in applying a wood finish is necessary if wood finish and plastics finish are to be comparable.



FLOOR TORCHIERE

Plate 61

Plate No. 61

FLOOR TORCHIERE

A companion piece for the table torchiere in Plate 60 is the *floor torchiere*. Obviously the kind of wood used and the finish applied should match as closely as possible. Ventilation details made necessary by heat from the light bulb are shown on Plate 60.

Wood will be conserved if the torchiere column is glued up in three pieces. Parallel lamp cord should be run through the post, therefore the long piece ($30\frac{1}{2}''$ in length to allow for a tenon at each end) must be glued up. It is recommended that a $3''$ square of rough turning stock be ripped $\frac{3}{16}''$ off center, a $\frac{3}{8}''$ groove be cut in the center of the larger part, and the parts glued together again. This leaves a $\frac{3}{8}''$ square channel for the wire.

It will be necessary to mount the base on a face plate for turning. An eleven-inch diameter disc can be mounted on a face plate, turned to dimensions, centered and drilled for a $\frac{3}{8}''$ dowel. A dowel can be inserted in the base center hole and used as a guide for all of the smaller discs until the required thickness is built up. If the torchiere cap is glued and turned with the base, as was recommended for the table torchiere, a lathe mounting operation will be eliminated.

The base for the plastics cylinder should be glued to necessary thickness and bored to fit a tenon on the long column. This part can be turned between centers. If a $36''$ lathe (between centers) is available, all parts of the post can be glued together as soon as the torchiere cap is turned and cut away; then final turning and sanding can be done.

A plastics cylinder must be mounted on a mandrel similar to that in Figure 75. A $\frac{5}{16}''$ hole is bored through the base to the center hole so that parallel lamp cord may be threaded through. Other wiring details are the same as on Plate 60. A push-type, canopy switch to control light is installed in the base.

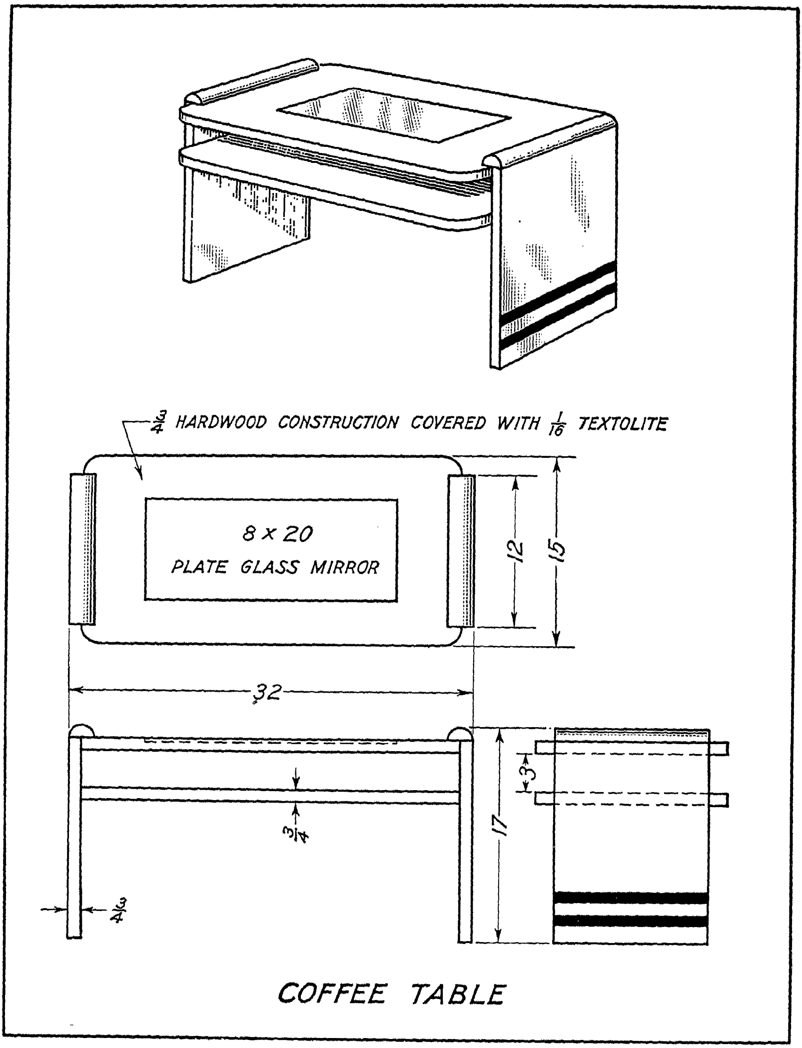
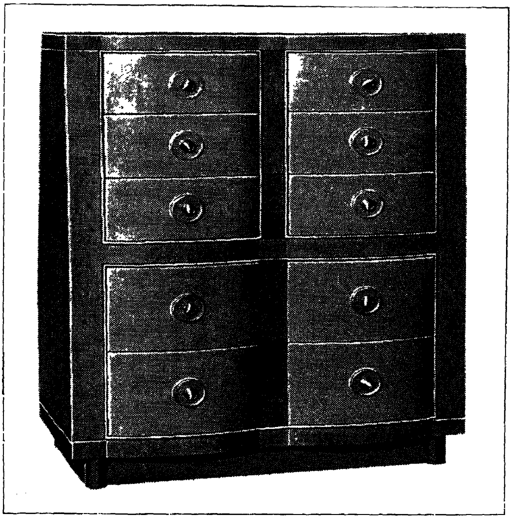

3/4 HARDWOOD CONSTRUCTION COVERED WITH 1/16 TEXTOLITE
8 x 20
PLATE GLASS MIRROR
12
15
32
3
3/4
17
3/4
COFFEE TABLE

Plate 62



(*Courtesy of the Saginaw Furniture Co.*)

Figure 151. Laminated chest of drawers in "Plastile" furniture.

Plate No. 62

COFFEE TABLE

Laminated plastics with a real wood surface has made possible the use of this modern material in the home as well as in the industrial field. Earlier plastics did not lend themselves to decorative purposes as do the recent developments.

The use of this modern material is suggested in the construction of the *coffee table* illustrated in Plate No. 62. Laminated plastics sheets, plate glass, and plywood join together to produce the smooth lines and durable surface of this table. The structure is basically wood, but the exposed finish is entirely of laminated plastics with a real wood surface.

The table is constructed from a cheap grade of $\frac{3}{4}''$ plywood, except for the two half-rounds which are made from a turned cylinder. The

top and sub-top should be layed out and carefully cut to size 15″ x 30¼″. The top is routed for an 8″ x 20″ plate mirror.

Veneers such as phenolic $\frac{1}{16}$″ thick or acetate with cloth backing are suitable for this type of construction. Available for selection according to preference are the following woods: walnut, mahogany, maple, prima vera, and rosewood. Veneer is cemented carefully on the edges and trimmed even with the surfaces. The top surfaces only are veneered since the underneath surfaces are not exposed. When applying veneer to a large surface, care must be taken to apply pressure evenly to all parts and the veneer must be held firmly until the cement hardens.

Two ends 12″ x 16⅛″ are required and the veneer is applied to the front, back, and inside surfaces in the usual way. Surplus stock should be left at the top of each edge veneer to cover the end of the half cylinder. The main top and sub-top are joined to the ends with a generous number of dowels. Flat head wood screws may be used between the dowels provided the heads are countersunk so they will not interfere with the veneer.

The half-cylinder is now ready to fasten in place. These should match the ends in width and should be slipped in place between the surplus stock left to cover the ends. Nails may be used to secure these pieces in place. At this time another problem presents itself—that of bending veneer to a form. A bending form should be made to match the semicircular ends. The plastics is then heated in hot water, which makes it pliable, before clamping it firmly in place. The semicircle and end down to the first inlay strip should be in one piece. When the veneer has set to the form it is removed and cemented in place. Two narrow strips of a solid color are suggested as inlays to finish the bottom of each end. The beauty of this table or other pieces of similar construction will depend largely on the ability of the craftsman to match and join the veneer accurately when two edges meet, either at a corner or on a flat surface.

Real wood veneers which have been cigarette-proofed may be purchased for a few cents additional. This type veneer makes desirable table tops, desk tops and store counters. Many stores are now featuring suites of furniture such as dining room, bedroom and study ensembles. A chest of drawers in "Plastile" furniture is illustrated in Figure 151.

Some of the outstanding qualities of this type of furniture are: the surface is waterproof, is not easily marred and is acid resisting.

It is hoped that the craftsman, either at home or in the laboratory, will find a use for this modern material and use it where lasting and permanent beauty is desired. Now that a new material has been found it is up to all craftsmen to develop and use it in the field of interior design whether it be for furniture or for structural purposes.

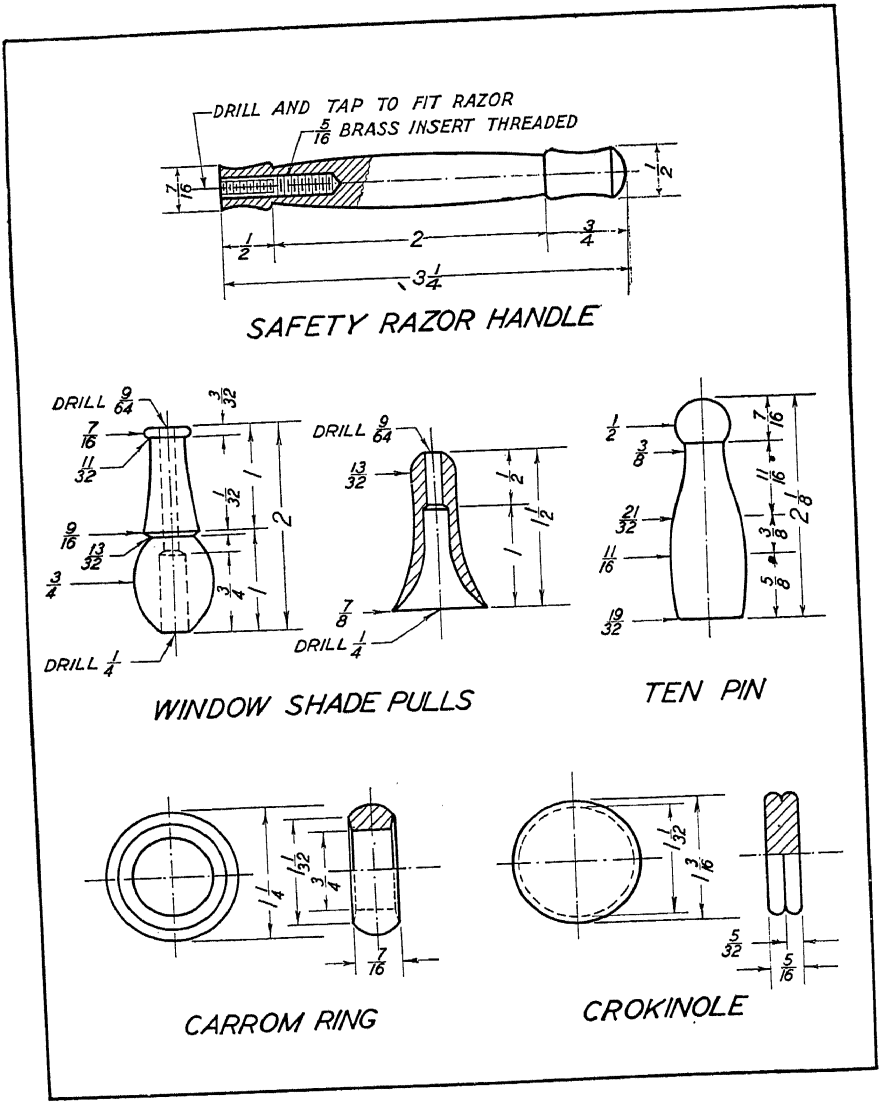

DRILL AND TAP TO FIT RAZOR
5/16 BRASS INSERT THREADED
7/16
1/2
1/2
2
3/4
3 1/4
SAFETY RAZOR HANDLE
DRILL 9/64
3/32
7/16
11/32
1/32
1
2
9/16
13/32
3/4
3/4
1
DRILL 1/4
DRILL 9/64
13/32
1/2
1 1/2
1
7/8
DRILL 1/4
WINDOW SHADE PULLS
1/2
3/8
7/16
11/16
2 1/8
21/32
3/8
11/16
5/8
19/32
TEN PIN
1 1/4
1 1/32
3/4
7/16
CARROM RING
1 1/32
1 3/16
5/32
5/16
CROKINOLE

Plate 63

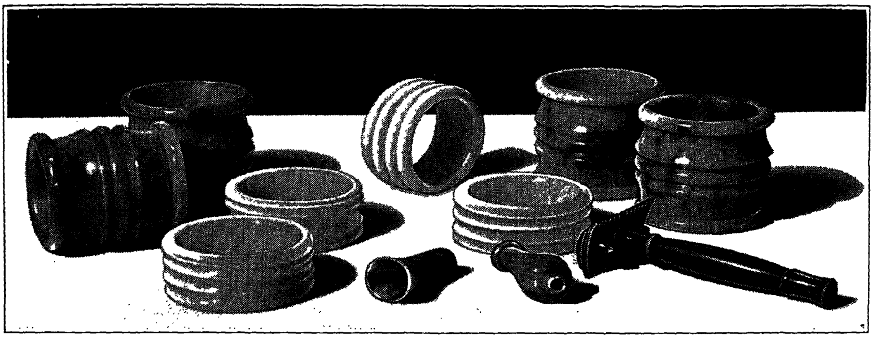


Figure 152. Shade pulls, napkin rings, and razor handles.

Plate No. 63

MISCELLANEOUS PARTS

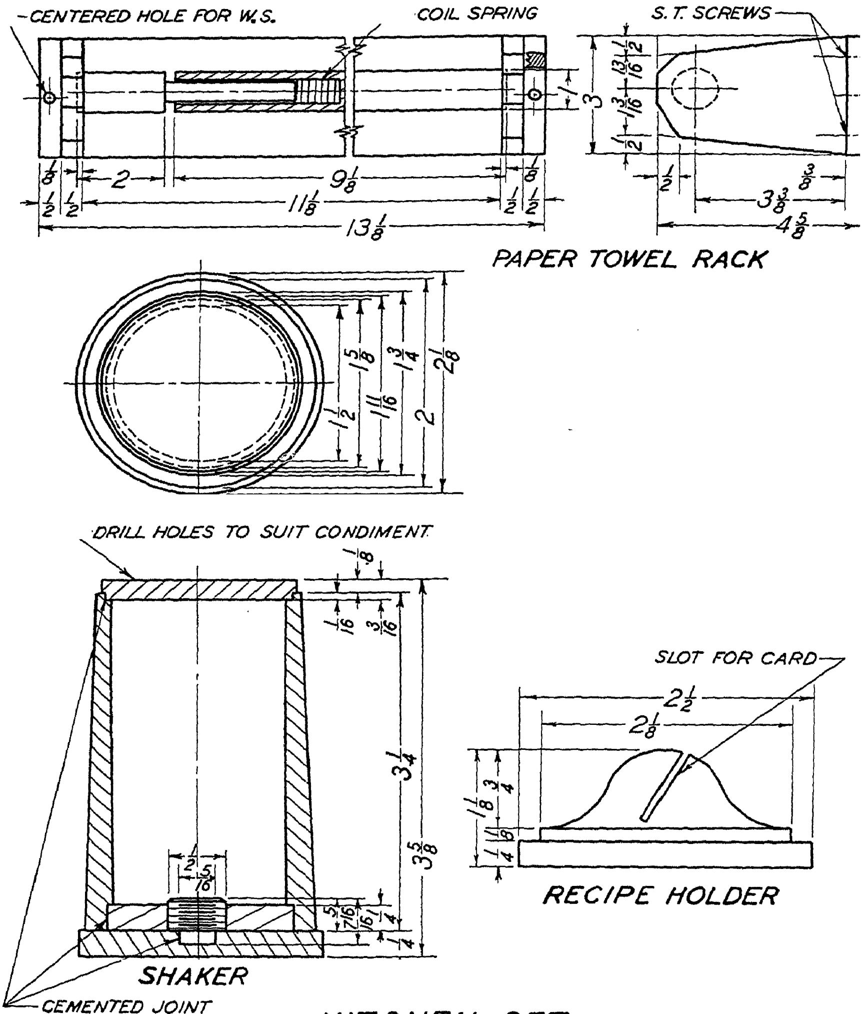
The usefulness of *safety razor handles* is increased if a metal insert can be secured for the tapped end of the handle. Metal inserts may be secured from a local plastics molding company or they may be turned from brass rods. An insert may be installed in the end of a rod of a size suitable for a razor handle (drilled to receive it) by heating the plastics and shrinking it on the insert or by cementing the insert in place with a plastics cement.

Window shade pulls are turned on small arbors which use a machine screw in the end. They must have a larger hole at the lower end to admit a knot in the shade cord.

A $\frac{3}{4}''$ round rod is used for turning *tenpins*. Each pin may be turned from a long rod held in a lathe chuck. If a $\frac{3}{4}''$ hollow chuck is not available in the laboratory, the stock may be mounted at the base end on an arbor.

Carrom rings may be turned most economically from a $1\frac{3}{8}''$ (O.D.) plastics cylinder with a $\frac{1}{2}''$ hole. Saw off the required number of blanks in a miter box, drill a $\frac{3}{4}''$ hole in the center of each piece, and mount on a spiral wooden arbor prepared for that purpose.

Crokinoles of one color may be turned from one rod held between centers. Enough waste between each disc should be left for cutting apart. Edges are smoothed and polished while in the lathe. The two faces must be sanded and buffed separately.


CENTERED HOLE FOR W.S.
COIL SPRING
S.T. SCREWS
PAPER TOWEL RACK
DRILL HOLES TO SUIT CONDIMENT
SLOT FOR CARD
RECIPE HOLDER
SHAKER
CEMENTED JOINT

KITCHEN SET

Plate No. 64

KITCHEN SET

Cast resinoids are colorful, sanitary materials which may be used in fabricating articles for kitchen use. All parts made from these materials may be washed with soap and water without losing color or surface finish. Foods which come in contact with the plastics are safe from the unpleasant odors arising from containers. The plastics, too, will not absorb food odors or moisture in harmful quantities.

The *paper-towel rack* is designed for roll towels and may be mounted on a kitchen cabinet or wall. The end supports may be mounted to the back panel with machine screws, self-tapping screws, or thread-producing screws. If the last two types of fastening devices are used, it is necessary to start all screws in a vertical position; otherwise a chip will be lifted from the plastics surface when the screws start to align themselves with pilot holes. A spring mounting for the towel rod eliminates removal of fastening devices when a new roll of towels is to be mounted.

A set of *shakers* may be made to match. Hole size in the shaker top must be adjusted to suit the contents. Two diameters on the shaker top make it possible for a rough-sawed plastics disc to be mounted for turning in a lathe chuck. Half of the thickness is turned and the disc reversed so that the other diameter can be turned. Both bottom discs may be mounted for turning on one of the arbors in Figure 72. All joints to be cemented should be fitted accurately so that joints will not show.

A *recipe holder* may be provided for holding recipe cards while a tasty dessert is being prepared. It is a simple lathe problem which can be mounted on an arbor for turning. Three discs may be cemented together if one thick piece is not available. A saw kerf provides the necessary card slot.

Color may be used on these kitchen articles. Bases for shakers and recipe holders and end supports on the towel rack may be made of a color which will match kitchen trim. These parts in pastel colors of green, blue, yellow, or orange combined with white as a body color, make an interesting combination.

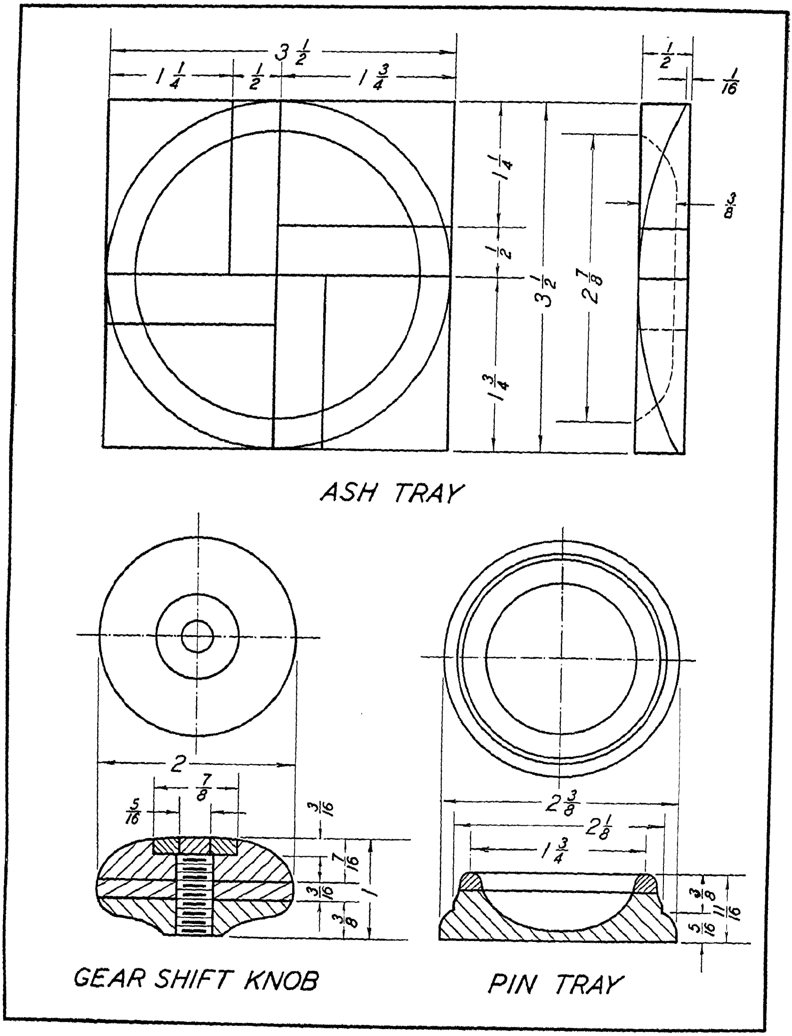


Plate 65

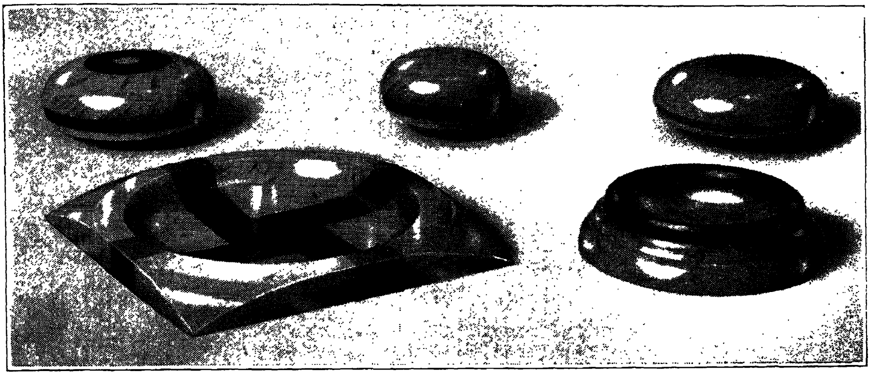


Figure 153. Vanity tray, gear-shift knobs, and pin tray.

Plate No. 65

VANITY TRAY, GEAR-SHIFT KNOB, AND PIN TRAY

It is possible, by laminating a problem, to provide an effect similar to inlaying. Geometric designs are possible as well. Color may be used to its best advantage in this type of work, for it is not necessary to make a break in the design in order to add color. Cemented joints must be well executed.

A laminated *vanity tray* is cemented in quarters and later as a whole unit. It is mounted on a face plate for turning. Accuracy in mounting is essential if all corners are to be of the same thickness.

A small hole filled with a wooden dowel in the center of a *gear-shift knob* will insure the parts remaining in proper position until the cement has time to set. It is usually drilled and tapped for a $\frac{3}{8}''$ N.F. (National Fine) thread. The thread must correspond to that of the gear-shift lever where it is to be used. A $\frac{3}{8}''$ N.F. arbor is used to mount the knob for turning. An inlay is added to the knob after the other turning has been done.

The *pin tray* shows a ring of different color around the top. This may be accomplished either by cementing a ring cut from a cylinder of the proper size or by a flat disc cut from a plastics sheet. Problems of

this type may be mounted on a face plate for turning. A piece of hardwood should be mounted on the face plate and two sheets of thin paper cemented between the laminated plastics block and the wood face. The use of paper between the cemented parts allows the plastics to be removed by using a sharp chisel or thin edge knife. Care should be taken not to chip the edges of the plastics with the chisel.

Clamps of various kinds may be used for holding laminated parts firmly together while the cement hardens. If "C" clamps are used the plastics surface should be protected by wood blocks. Bar clamps, vises, and other metal holding devices should have wood inserts to protect the plastics. When adjustable hand screws are used care must be taken to keep the jaws parallel.

In cementing right-angled edges, such as those shown in the vanity tray, the corners and edges *must* be accurately fitted or the parts will have a tendency to slip while being cemented. Small metal dowels may be used to aid in preventing the parts from shifting position. Again the neatness and accuracy of the craftsman will play an important part.

Appendix A

Supplementary Information

CELLULOSE NITRATE

The base of cellulose-nitrate (or pyroxylin) plastics is cotton, as is the case with cellulose acetate. Cotton linters are treated with nitric acid and sulphuric acid to make them soluble and workable. Because of the inflammable nature of pyroxylin, there is considerable danger connected with raw materials and with the manufacturing processes. Fabricated materials are also somewhat dangerous if they are stored in large quantities.

Hyatt used camphor both as a solvent and as a plasticizer when he made his discoveries. Alcohol has been added to camphor for a solvent material. During the manufacturing process, to remove much of the volatile matter, the pieces are cured at high temperatures for a length of time depending upon their thickness.

Pyroxylin is strong, tough, and wear-resistant. These qualities make it adaptable for the covering of many articles such as shoe heels, mirror backs, and harness rings. It resists dimensional changes; a quality which makes it suitable for use in precision instruments such as slide rules, draftsmen's triangles, and curves. A peculiar quality enables it to be stretched within its elastic limit when heated and set in this position by quick cooling. In this stretched condition, it may be placed over towel bars and the like. The stretched material is released by reheating and tends to return to its original shape at a normal rate of cooling.

There are many solvents for cellulose nitrate which will soften but not dissolve the plastics. In veneering, a sheet is softened, stretched over a wood form, and allowed to shrink as it dries. Cementing the plastics to itself may be accomplished by softening with acetone, ethyl acetate, or butyl acetate, and pressing together. Pyroxylin plas-

tics are cemented to other materials (53-94) "by the use of body cements containing cellulose nitrate, plasticizers, and solvents."

Because of the nature of cellulose-nitrate resinoid, color possibilities are unlimited. Sheets may be polished, may have a matt finish, or may be embossed. Printed designs may be impressed upon pyroxylin surfaces. Even though these plastics are widely used, many of the manufacturers produce cellulose-acetate plastics also.

Properties: specific gravity 1.35-1.40, compression molded, burns very rapidly, decomposes under strong acids and strong alkalies, machines readily, discolors and becomes brittle under sunlight, has unlimited color possibilities.

CELLULOSE ACETATE

The raw compounds which are combined to produce this resinoid are: cotton linters, glacial acetic acid, and acetic anhydride. Since cellulose acetate burns slowly like heavy cardboard, wood, and similar materials, it is non-hazardous either in manufacture or in use. Cellulose acetate is an expensive plastics because of the costly organic acid with which it is made.

This resinoid is, in its original form, clean and transparent, which property permits a great variety of colors. The variety of colors along with the strength and resiliency of the material accounts for its wide use. The cellulose-acetate plastics is available both as a molding powder from which knife handles, door knobs, commercial machine keys, combs, hair ornaments, and radio parts are molded; and as raw material from which other articles may be fabricated by machine processes. Molding powder, under various trade names, presents the unique "possibility of 'custom-made' colors to harmonize with draperies, upholstery, and household and automobile hardware" (56-98).

Properties: specific gravity 1.27-1.37, excellent molding properties, burns slowly, decomposes under strong acids and strong alkalies, machines readily, has unlimited color possibilities.

CELLULOSE ACETATE BUTYRATE

These plastics are produced from materials similar to the cellulose-acetate plastics above except that butyric acid is added to the process.

Less pressure is required for molding, and a more clearly defined melting point may be reached.

Properties: specific gravity 1.14-1.22, excellent molding properties, burns slowly, decomposes under strong acids and strong alkalies, machines readily, has unlimited color possibilities.

ETHYLCELLULOSE

Ethylcellulose has recently been introduced commercially in this country. Its outstanding characteristics are toughness and thermoplasticity. These characteristics make the plastics adaptable for extrusions in the form of long rods of small cross-section and in the form of wire coatings.

Properties: specific gravity 1.14, excellent molding properties, burns slowly, decomposes under strong acids but unaffected by alkalies, machines readily, has unlimited color possibilities.

ACRYLATES

The acrylic resinoids approach the realization of an organic glass. A thermoplastic with 90 to 92 per cent visible light transmission under the name "Plexiglas" is available. "Plexiglas" transmits from 50 to 70 per cent of ultra-violet light. A sheet of this material may be bent into two-dimensional forms, which quality makes it suitable for vehicle windows. Optical properties necessary for prisms and lenses are claimed for this resinoid.

Methyl methacrylate plastics made from cotton, camphor, crude petroleum oil, mixed acid, and coal are recent developments. In addition to the crystal clear castings with perfect transparency, the plastics is available in brilliant transparent, translucent, and opaque colors.

A variety of acrylic resinoids, ranging from a soft, sticky viscous mass to thermoplastics solids, are produced. The softer materials are used as binders for wood, textiles, metals, glass, and rubber. Flexibility, freedom from bacterial and fungous deterioration, and transparent bonds are thus possible. Metal coatings and leather finishes from these resinous materials require no baking. Polymethyl methacrylate is made into cast sheets, which are used for aircraft enclosures and furniture. Recent furniture exhibitions have featured entire units of "Plexiglas" and "Lucite" furniture.

Properties: specific gravity 1.18-1.19, cast or molded readily, burns slowly, affected slightly by acids and alkalies, excellent machinability, excellent clarity, has unlimited color range.

COUMARONE-INDENE

Both coumarone and indene are obtained from the same fractional distillation of coal tar. The distillation temperatures range from 150 to 200 degrees C. Coumarone (72-65) is "a water-white oily liquid which boils at 342 degrees F." "Indene is a colorless liquid which boils at approximately 360 degrees F. and solidifies at 218 degrees F. to form crystals." These resinoids are well adapted for the manufacture of floor tile because they are not affected by caustic alkalies, potassium cyanide, aqueous ammonia, or hydrochloric acid. This quality is, in a measure, responsible for the 50 million square feet of mastic floor tile which are produced annually.

The color range of the indene plastics is from pale, transparent yellow through the browns to black. An outstanding weakness of this type of plastics is its brittleness, though it is possible to overcome much of this difficulty through the use of improved plasticizers. These plastics range from very soft, which softens at around 80 degrees F., to the very hard, which softens around 123 degrees F.

Additional uses for the coumarone-indene plastics include varnish for printers inks, paints, acid resisting coatings for tanks, waterproofing agents, and laminated products. The future of these resinoids seems to lie (46-105) in connection with amplifying and supplementing thermosetting and other thermoplastics resinoids.

Properties: specific gravity 1.08-1.14, excellent thermoplasticity, acid, alkali, and water resistant, has high electric breakdown.

VINYL

Polymerized vinyl ester, polymerized acetate, and polyvinyl chloride are the bases for vinyl resinoids. These resinoids may be polymerized with resinoids in other groups to form plastics with new properties.

This resinoid retains its thermoplastic nature even when molded. It is possible, therefore, to remold the plastics. This plastic nature

enables it to be used with glass and other firm solids to absorb expansion at joints. It is used as a surfacer and as an impregnating material for cloth and fabrics. Records for electrically-transcribed programs are made from vinyl. Since it is odorless, tasteless, and acid-resistant, it may be used for beverage containers, food containers, and dentures.

Properties: specific gravity 1.34-2.5, injection and compression molded, will not burn, vinyl chloride discolors under sunlight, little or no effect from strong acids and alkalies, machines readily, has color range limited only by fillers.

LIGNIN

Properties: specific gravity 1.45, compression molded, burns slowly, decomposes under strong alkalies, attacked by oxydizing acids, machines readily, and available in opaque colors only.

STYRENE

"Styrene is a colorless liquid, boiling at 146 degrees Centigrade, and having a density of .925. It is readily converted into solid polystyrene by heating, with or without catalysts" (73-38). Even though it is one of the older resinoids, its development has lagged behind that of many others because of inadequate manufacturing methods. The more practical methods of manufacturing in use in the United States and Europe today point toward a rapid development in the near future. Raw materials are available in quantities at comparatively low cost. Polystyrene is prepared in molded and sheet form. It may be machined after molding.

Properties: specific gravity 1.054-1.07, burns slowly, excellent molding qualities, unaffected by acids and alkalies, machines readily, has unlimited color range.

CASEIN

Properties: specific gravity 1.35, moldable with difficulty, burns very slowly, decomposes under strong acids and strong alkalies, machines readily, has wide color range.

PHENOL-FORMALDEHYDE

The phenol-formaldehyde plastics is the most important of the coal-tar derivatives. In volume of production, it surpasses any other type of plastics. It is, perhaps, the most diversified of the plastics, since

it is used for cast, laminated, and molded forms. Practically any of the fillers are used in the manufacture of molding compositions, thus making a variety of properties possible with the same type of plastics.

Properties: specific gravity 1.25-2.09 (depending upon the nature of the filler), compression and injection molded with fillers, compression molded without filler, laminated with fabric, paper, and asbestos base, cast with no filler, very low to nil burning rate, colors may change when exposed to sunlight, decomposes under oxidizing acids, decomposes under strong alkalies, machining qualities fair to excellent, transparent, translucent, and opaque, depending upon filler or base laminates; limited color range except in cast form.

PHENOL-FURFURAL

The commercial value of phenol-furfural resinoids was determined prior to 1920. At that time, however, it was too expensive for commercial development (54-33)—it sold for thirty-five dollars per pound. The plastics is produced from farm cellulose waste and, for this reason, it should be produced in much larger quantities in the future.

In the curing process, furfural resinoid hardens so completely that there is little danger of its warping out of shape. This property permits molded articles with thinner walls than is possible with other molding compounds.

Properties: specific gravity 1.3-2.0, compression and injection molded with fillers, burns slowly to nil depending upon filler, light colors will discolor under exposure to sunlight, decomposes under strong alkalies and oxidizing acids, machines readily, is limited to opaque colors.

UREA-FORMALDEHYDE

Properties: specific gravity 1.45-1.5, compression molded readily, burns slowly, decomposes under strong acids and strong alkalies, machines readily, unaffected by sunlight, has unlimited color range (lends itself to pastel colors particularly).

NYLON

Properties: specific gravity 1.14, burns very slowly, attacked only by oxidizing acids, unaffected by alkalies, has unlimited color possibilities.

Important Dates in Plastics Progress

1773—A compound called *urea* was discovered in the urine of mammals and other of the higher forms of animal life.
1828—Urea was produced synthetically by Woehler.
1838—Regnault (14-1) discovered a white powder formed in sealed tubes of vinyl chloride placed in the sunlight.
1839—An Englishman, Taylor, obtained a patent for vulcanized fiber.
1843—Redtenbacher (31-32) reported a preparation of acrylic acid.
1845—Styrene was described and defined accurately by Blythe and Hoffman.
1846—Dr. Schonbein, an English science teacher, discovered, while teaching in Switzerland, a nitro-cellulose compound in solution.
1856—Sir William Pekin introduced to industry the first practical synthetic dye, "aniline purple."
1865—Cellulose acetate was first produced in a scientific laboratory.
1868—First American plastics. John Wesley Hyatt used camphor as a solvent and as a plasticizer, treated cellulose with nitric acid, and produced a nitrocellulose solid.
1869—First American plastics patent issued to John W. and Isiah S. Hyatt.
1872—Bayer (68-20) recorded that a resin-like substance could be made from phenol and formaldehyde.
1872—E. Bauman succeeded in polymerizing vinyl halides which were "unaffected by solvents or acids" (14-1).
1880—Screw-type extruding machine invented by Vernon Royle.
1890—The development of *casein* plastics, by Adolph Spitteler, started with a mixture of sour milk and formaldehyde.
1890—Coumarone and indene isolated from coal tar and polymerized with sulphuric acid by Spilker and Kraemer.
1897—First patent for casein secured by Spitteler and Kirsche.
1901—Dr. Otto Röhm published the results of his researches with acrylic resinoids.
1903—First patent for cellulose acetate. It was not developed at that time.
1909—First patent for *phenol-formaldehyde* plastics secured by Dr. Leo H. Baekeland. Redman and Aylesworth in America, and Raschig in Germany were contemporaries in the development of this plastics. Three manufacturing companies were organized but later merged into the Bakelite Corporation in 1922.
1909—Bitumen, or cold-molded plastics, introduced to the commercial market by Emil Hemming.
1926—Expiration of original patent rights on phenol-formaldehyde.
1927—Cellulose acetate plastics appear on the commercial market.
1928—Cast phenolics placed on the market.
1928—Vinyl resinoids—Carbide and Carbon Chemicals Corporation.
1929—*Urea-formaldehyde* appeared when the foreign patent rights were purchased by the American Cyanamid Corporation.
1931—Acrylic resinoids, produced by Röhm & Haas Co., appeared in the industrial picture.
1934—First injection molding press was introduced into the United States.
1935—Ethylcellulose was manufactured in the United States by the Hercules Powder Co.
1937—"Styron," from *styrene,* was introduced by the Dow Chemical Co.

Table III

PRODUCTION OF SYNTHETIC RESINOIDS IN THE UNITED STATES

Plastics Materials*

TYPE OF PLASTICS	1939		1937	
	QUANTITY IN POUNDS	VALUE	QUANTITY IN POUNDS	VALUE
Nitro cellulose	11,207,637	8,495,519	14,850,817	12,526,206
Cellulose acetate				
Sheets, rods, and tubes	8,743,139	6,588,247	18,923,663	12,199,744
Molding compositions	11,537,032	5,222,946	....	....
Coal tar resins	136,885,088	26,372,357	131,568,162	23,583,627
Other plastics (including synthetic rubber)	....	31,300,806	....	13,568,113

Plastics Products*

	1939	1937
Value of plastics products	$71,904,067	$62,139,479
Value added by manufacture	40,156,982	35,499,842

Specific Products Containing Some Plastics Materials (1939)*

PRESENT GROUP	VALUE OF PRODUCTS
Fabricated plastics products	$ 93,788,471
Artificial leather	21,511,342
Brushes	9,330,694
Buttons	8,304,295
Dental equipment and supplies (except rubber)	1,411,805
Games and toys (except dolls and vehicles)	542,671
Millinery (synthetic textile trimmed)	5,324,296
Mirrors and glass (principally safety glass)	40,395,225
Ophthalmic goods (lens and fittings)	2,516,257
Paints, varnishes, and lacquers	137,294,452
Pens, mechanical pencils and pen points	16,351,261
Photographic apparatus (materials and projection unit)	65,729,734
Rayon and allied products	247,065,556
Radios, radio tubes, and phonographs	19,761,884

* Compiled from U. S. Census of Manufacturers. 1939.

Table IV

Cast Resinoids

TRADE NAME	DESCRIPTION	MANUFACTURER
Ameroid	Casein	American Plastics Corporation, New York City.
Bakelite	Phenolic Cast	Bakelite Corporation, New York City.
Bendalite	Cast Styrene	Bend-A-Lite Plastics, Chicago, Ill.
Catalin	Cast Phenolic	Catalin Corporation, New York City.
Celate	Cellulose Acetate	E. L. Cournand, Inc., New York City.
Gemstone	Phenol-formaldehyde	A. Knoedler Co., Lancaster, Pa.
Joanite	Cast Resin	Lapin Products, Inc., New York City.
Lucite	Methyl Methacrylate Resin	E. I. du Pont de Nemours & Co., Inc., Plastics Division, Arlington, N. J.
Lumarith	Cellulose Acetate	Celanese Celluloid Corporation, New York City.
Marblette	Phenolic	Marblette Corporation, Long Island City, New York.
Metex	Thermoplastic	E. L. Cournand, Inc., New York City.
Opalon	Phenol-formaldehyde	Monsanto Chemical Co., Springfield, Mass.
Plexiglas	Acrylic	Röhm & Haas Co., Inc., Philadelphia, Pa.
Prystal	Phenol-formaldehyde	Catalin Corporation, New York City.
Ronyx	Corn Protein	Resinox Corporation, New York City.

Molding Compounds

Aceloid	Cellulose Nitrate	American Cellulose Co., Indianapolis, Ind.
Aceplus	Cellulose Acetate	American Cellulose Co., Indianapolis, Ind.
Acwalite	Cellulose Acetate and Cellulose Nitrate	Celanese Celluloid Corporation, New York City.

Molding Compounds—(Continued)

TRADE NAME	DESCRIPTION	MANUFACTURER
Aico	Cold Molds	American Insulation Corporation, New Freedom, Pa.
Aico-5	Cold Molded	American Insulator Corporation, New Freedom, Pa.
Alphide	Cold Molded	Standard Plastics Corporation, Jersey City, N. J.
Alvar	Vinyl	Shawinigan Prod. Corporation, New York City.
Amerine	Cold Molded	American Insulator Corporation, New Freedom, Pa.
Ameroid	Casein	American Plastics Corporation, New York City.
Amphenol	Polystyrene	American Phenolic Corporation, Chicago, Ill.
Bakelite	Phenol-formaldehyde and Urea-formaldehyde	Bakelite Corporation, New York City.
Beetle	Urea-formaldehyde	Plastics Division, American Cyanamid Co., New York City.
Butacite	Butyral	E. I. du Pont de Nemours & Co., Inc., Wilmington, Del.
Butvar	Butyral	Shawinigan Products Corporation, New York City.
Caffelite	Protein from Green Coffee Beans	Caffelite Corp., New York City.
Catamold	Phenol-formaldehyde	Catalin Corporation, New York City.
Celastic	Cellulose Nitrate	Celastic Corporation, Arlington, N. J.
Celluloid	Cellulose Nitrate	Celanese Celluloid Corporation, New York City.
Celeron	Phenolic	Continental-Diamond Fibre Co., Newark, Del.
Cetec	Cold Molded	General Electric Co., Plastics Division, Pittsfield, Mass.
Cibanite	Analine-formaldehyde	Ciba Co., Inc., New York City.
Colasta	Phenolic	Specialty Insulation Mfg. Co., Hoosick Falls, New York.

Molding Compounds—(Continued)

TRADE NAME	DESCRIPTION	MANUFACTURER
Coltstone	Cold Molded	Colt's Patent Fire Arms Mfg. Co., Hartford, Conn.
Coltwood	Phenolic	Colt's Patent Fire Arms Mfg. Co., Hartford, Conn.
Coronation	Casein	George Morrell Corporation, Muskegon Hts., Mich.
Crystalite	Acrylic	Röhm & Haas Co., Inc., Philadelphia, Pa.
Durez	Phenolic	Durez Plastics & Chemicals, Inc., North Tonawanda, New York.
Durite	Phenol-formaldehyde	Durite Plastics, Inc., Philadelphia, Pa.
Ebrok	Cold Molded	Richardson Co., New York City.
Ethocel	Ethyl Cellulose	Dow Chemical Co., Midland, Mich.
Ethocel PG	Ethyl Cellulose	Dow Chemical Co., Midland, Mich.
Fibestos	Cellulose Acetate	Monsanto Chemical Co., Springfield, Mass.
Formvar	Vinyl	Shawinigan Products Corporation, New York City.
Gala	Casein	George Morrell Corporation, Muskegon Hts., Mich.
Galorn	Casein	George Morrell Corporation, Muskegon Hts., Mich.
Garit	Cold Molded	Garfield Mfg. Co., Garfield, N. J.
Gemloid	Cellulose Acetate and Cellulose Nitrate	Gemloid Corporation, Elmhurst, L. I., New York.
Gummon	Cold Molding	Garfield Mfg. Co., Garfield, N. J.
Harvite	Shellac	Siemon Co., New York City.
Hemit	Cold Molded	Garfield Mfg. Co., Garfield, N. J.
Hercose AP	Cellulose Acetate Propionate	Hercules Powder Co., Wilmington, Del.
Hercules	Cellulose Acetate	Hercules Powder Co., Wilmington, Del.

Molding Compounds—(Continued)

TRADE NAME	DESCRIPTION	MANUFACTURER
Herculoid	Cellulose Nitrate	Hercules Powder Co., Wilmington, Del.
Heresite	Phenolic	Heresite & Chemical Co., Manitowoc, Wis.
Indur	Phenolic	Reilly Tar & Chemical Co., New York City.
Insurok	Phenolic and Urea	Richardson Co., Melrose Park, Chicago, Ill.
Lacanite	Shellac	Consolidated Molded Products Corp., Scranton, Pa.
Loalin	Polystyrene	Catalin Corporation, New York City.
Lucite	Acrylate-methacrylate	E. I. du Pont de Nemours & Co., Inc., Arlington, N. J.
Lumarith	Cellulose Acetate	Celanese Celluloid Corporation, New York City.
Lusterloid	Cellulose Nitrate	Lusterloid Container Co., S. Orange, N. J.
Lustron	Polystyrene	Monsanto Chemical Co., Springfield Mass.
Makalot	Phenolic	Makalot Corporation, Boston, Mass.
Melmac	Melamine Aldehyde	Plastics Division, American Cyanamid Co. New York City.
Methocel	Methyl Cellulose	Dow Chemical Co., Midland, Mich.
Moldarta	Phenolic	Westinghouse Elec. & Mfg. Co., Trafford, Pa.
Monsanto CA	Cellulose Acetate	Monsanto Chemical Co. Springfield, Mass.
Monsanto Vinyl	Vinyl	Monsanto Chemical Co. Springfield, Mass.
Neillite	Phenol-formaldehyde	Watertown Mfg. Co., Watertown, Conn.
Nitron	Cellulose Nitrate	Monsanto Chemical Co., Springfield, Mass.
Nixonid	Cellulose Nitrate	Nixon Nitration Works, East Nixon, N. J.
Nixonite	Cellulose Acetate	Nixon Nitration Works, East Nixon, N. J.

Molding Compounds—(Concluded)

TRADE NAME	DESCRIPTION	MANUFACTURER
Okron	Cold Molding	American Hard Rubber Co., New York City.
Plaskon	Urea-formaldehyde	Plaskon Co., Inc., Toledo, Ohio.
Plastacele	Cellulose Acetate	E. I. du Pont de Nemours & Co., Inc., Arlington, N. J.
Plastine	Cellulose Nitrate	Sillcocks-Miller Co., South Orange, N. J.
Pyralin	Cellulose Nitrate	E. I. du Pont de Nemours & Co., Inc., Arlington, N. J.
Resinox	Phenol-formaldehyde	Resinox Corporation, Monsanto Chemical Co., Springfield, Mass.
Ryercite	Phenolic	Jos. T. Ryerson & Son, Inc., Chicago, Ill.
Saran	Vinylidene	Dow Chemical Co., Midland, Mich.
Styron	Polystyrene	Dow Chemical Co., Midland, Mich.
Tegit	Cold Molded	Garfield Mfg. Co., Garfield, N. J.
Templus	Phenolic	The Bryant Electric Co., Bridgeport, Conn.
Tenite I	Cellulose Acetate	Tennessee Eastman Corporation, Kingsport, Tenn.
Tenite II	Cellulose Acetate Butyrate	Tennessee Eastman Corporation, Kingsport, Tenn.
Textolite	Phenolic	General Electric Co., Plastics Division, Pittsfield, Mass.
Thermo-plax	Cold Molding	Cutler-Hammer, Inc., Milwaukee, Wis.
Uniplast	Phenolic	Universal Plastics Co., New Brunswick, N. J.
Vinylite	Vinyl	Carbide & Carbon Chemicals Corp., New York City.
Vinylite X	Butyral	Carbide & Carbon Chemicals Corp., New York City.
Zalmite	Phenolic	Simmons Co., Kenosha, Wis.

Laminates

TRADE NAME	DESCRIPTION	MANUFACTURER
Aqualite	Phenol-formaldehyde	National Vulcanized Fibre Co., Wilmington, Del.
Beetle	Urea-formaldehyde	Beetle Products Division, American Cyanamid Co., New York City.
Benalite	Lignin	Masonite Corporation, Laurel, Miss.
Catabond	Phenolic	Catalin Corporation, New York City.
Cellanite	Phenolic	Continental-Diamond Fibre Co., Newark, Del.
Cellulak	Laminated tubing	Continental-Diamond Fibre Co., Newark, Del.
Celluloid	Cellulose Acetate	Celanese Celluloid Corporation, New York City.
Celoron	Phenolic	Continental-Diamond Fibre Co., New York City.
Diamond	Cotton cellulose	Continental-Diamond Fibre Co., Newark, Del.
Dilecto	Phenol-formaldehyde	Continental-Diamond Fibre Co., Newark, Del.
Duraloy	Phenol-formaldehyde	Detroit Paper Products Corporation, Detroit, Mich.
Formica	Phenol-formaldehyde and Urea-formaldehyde	Formica Insulation Co., Cincinnati, Ohio.
Haskelite	Phenolic	Haskelite Mfg. Co., Chicago, Ill.
Insurok	Phenol-formaldehyde and Urea-formaldehyde	Richardson Co., Chicago, Ill.
Lamicoid	Phenol-formaldehyde and Urea-formaldehyde	Mica Insulation Co., New York City.
Micabond	Phenolic	Continental-Diamond Fibre Co., Newark, Del.
Micarta	Phenol-formaldehyde and Urea-formaldehyde	Westinghouse Electric & Mfg. Co., Trafford, Pa.
Micoid	Phenolic	Mica Insulation Co., New York City.
Ohmoid	Phenolic	Wilmington Fibre Specialty Co., E. Wilmington, Del.
Panelyte	Phenolic	Panelyte Corporation, New York City.

Laminates—(Continued)

TRADE NAME	DESCRIPTION	MANUFACTURER
Parkwood Textolite	Phenolic or Urea	Parkwood Corporation, Wakefield, Mass.
Peerless	Insulation	National Vulcanized Fibre Co., Wilmington, Del.
Phenolite	Phenolic	National Vulcanized Fibre Co., Wilmington, Del.
Plexigum	Acrylate	Röhm & Hass Co., Inc., Philadelphia, Pa.
Pregwood	Phenolic	Formica Insulation Co., Cincinnati, Ohio.
Realwood	Phenolic and Urea surface	Formica Insulation Co., Cincinnati, Ohio.
Reziwood	Phenolic	I. F. Laucks, Inc., Seattle, Wash.
Spauldite	Phenolic	Spaulding Fibre Co., Tonawanda, New York.
Synthane	Phenolic	Synthane Corporation, Oaks, Pa.
Taylor	Phenolic	Taylor Fibre Co., Norristown, Pa.
Textolite	Phenolic	General Electric Co., Plastics Division, Pittsfield, Mass.
Ucinite	Phenolic	United-Carr Fastener Corporation, Cambridge, Mass.
Uformite	Urea-formaldehyde	Resinous Products & Chemicals Co., Inc Philadelphia, Pa.
Vulcoid	Phenolic	Continental-Diamond Fibre Co., Newark, Del.

Surface Coatings

Abalyn	Methyl Abietate	Hercules Powder Co., Wilmington, Del.
Acryloid	Acrylic	Resinous Products & Chemical Co., Inc., Philadelphia, Pa.
Acrysol	Acrylic	Resinous Products & Chemical Co., Inc., Philadelphia, Pa.
Aero Ester Gum	Rosin-glycerol	American Cyanamid Co., New York City.
Akco	Phenolic	American Cyanamid Co., New York City.

Surface Coatings—(Continued)

TRADE NAME	DESCRIPTION	MANUFACTURER
Alvar	Vinyl	Shawinigan Products Corporation, New York City.
Amberlac	Alkyd	Resinous Products & Chemical Co., Inc., Philadelphia, Pa.
Amberol	Phenolic	Resinous Products & Chemical Co., Inc., Philadelphia, Pa.
Aroclor	Chlorinated Diphenyl	Monsanto Chemical Co., Springfield, Mass.
Beetle	Urea-formaldehyde	Plastics Division, American Cyanamid Co., New York City.
Catavar	Phenolic	Catalin Corporation, New York City.
Complac	Shellac	Poinsettia, Inc., Pitman, N. J.
Compo-Site	Shellac	Compo-Site, Inc., Newark, N. J.
Cumar	Coumarone Indene	The Barrett Co., New York City.
Duraplex	Alkyd	Resinous Products & Chemical Co., Philadelphia, Pa.
Esterol	Alkyd	Paramet Chemical Corporation, Long Island City, New York.
Fiberlac	Cellulose Nitrate	Monsanto Chemical Co., Springfield, Mass.
Formvar	Vinyl	Shawinigan Products Corporation, New York City.
G	Glycerolphthalic Anhydride	Makalot Corporation, Boston, Mass.
Gelva	Vinyl	Shawinigan Products Corporation, New York City.
Gem-Cote	Plastic Finishing	Gemloid Corporation, Elmhurst, L. I., New York.
Glyptal	Alkyd	General Electric Co., Bridgeport, Conn.
Harvel	Resin	Irvington Varnish & Insulator Co., Irvington, N. J.
Harvite	Shellac	Siemon Co., Bridgeport, Conn.
Heresite	Phenolic	Heresite & Chemical Co., Monitowoc, Wis.

Surface Coatings—(Continued)

TRADE NAME	DESCRIPTION	MANUFACTURER
Imperial Ester	Rosin-glycerol	J. D. Lewis, Providence, R. I.
Insulate	Shellac	Insulation Mfg., Co., Brooklyn, New York.
Lacanite	Shellac	Consolidated Molded Products Co., Scranton, Pa.
Lewisol	Alkyd	J. D. Lewis, Inc., Providence, R. I.
Loavar	Styrene	Catalin Corporation, New York City.
Macoid	Nitro Cellulose	Detroit Macoid Corporation, Detroit, Mich.
Makalot	Phenolic	Makalot Corporation, Boston, Mass.
Mirasol	Alkyd	Carbogen Chemical Co., Garwood, N. J.
Neville Resin	Coumarone Indene	Neville Co., Pittsburgh, Pa.
Nevindene	Coumarone Indene	Neville Co., Pittsburgh, Pa.
Norbo	Phenolic	Bakelite Corporation, New York City.
Paradura	Phenolic	Paramet Chemical Corporation, Long Island City, New York.
Paramet Ester Gum	Rosin-Glycerol	Paramet Chemical Corporation, Long Island City, New York.
Paranol	Phenolic	Paramet Chemical Corporation, Long Island City, New York.
Paraplex	Alkyd	Resinous Products & Chemical Co., Inc., Philadelphia, Pa.
Petrex	Terpinene Maleic Anhydride	Hercules Powder Co., Wilmington, Del.
Phenac	Phenolic	American Cyanamid Co., New York City.
Piccolyte	Terpene Resin	Penn Industrial Chemical Co., Clairton, Pa.
Piccoumaron	Terpene Resin	Penn Industrial Chemical Co., Clairton, Pa.
Primal	Acrylate	Röhm & Haas Co., Inc., Philadelphia, Pa.

Surface Coatings—(Concluded)

TRADE NAME	DESCRIPTION	MANUFACTURER
Rauzene	Phenolic	U. S. Industrial Alcohol Co., Newark, N. J.
Rauzite	Urea	U. S. Industrial Alcohol Co., Newark, N. J.
Rauzone	Alkyd	U. S. Industrial Alcohol Co., Newark, N. J.
Rezyl	Alkyd	American Cyanamid Co., New York City.
Santolite	Toulene Sulfonamid Formaldehyde	Monsanto Chemical Co., Springfield, Mass.
Speedolaq	Plastic Lacquers	Speedolaq Products Co., St. Paul, Minn.
Tec	Cellulose Acetate	Tennessee Eastman Corporation, Kingsport, Tenn.
Teglac	Alkyd	American Cyanamid Co., New York City.
Tego	Phenolic	Resinous Products & Chemical Co., Philadelphia, Pa.
Vinsol Resin	Thermoplastic	Hercules Powder Co., Inc., Wilmington, Del.
Vinylite	Vinyl	Carbide and Carbon Chemicals Corp., New York City.

Adhesives

Ecolac	Air-drying lacquer and adhesive for plastics	Maas & Waldstein Co., Newark, N. J.
Lauxite	Urea-formaldehyde	Merritt Engineering & Sales Co., Inc., Lockport, New York.
Norbo	Phenolic	Bakelite Corporation, New York City.
Plastiglue	Adhesive	Schwab & Frank, Inc., Detroit, Mich.
Tego	Phenolic	Resinous Products & Chemical Co., Inc., Philadelphia, Pa.

Miscellaneous

Adheso	Synthetic wax	Glyco Products Co., Inc., New York City.
Aristocrat	Sun glasses	Athol Comb Co., New York City.

Miscellaneous—(Continued)

TRADE NAME	DESCRIPTION	MANUFACTURER
Cellophane	Cellulose wrapping	E. I. du Pont de Nemours & Co., Inc., Wilmington, Del.
Cellucraft	Nitro cellulose spray coating	Detroit Macoid Corporation, Detroit, Mich.
Cellulak	Shellac paper-laminated tubing	Continental-Diamond Fibre Co., Newark, Del.
Celocards	Acetate Christmas cards	Celomat Corporation, New York City.
Cel-O-Glass	Acetate-coated wire screen	Acetol Products, Inc., New York City.
Celomats	Acetate table place mats	Celomat Corporation, New York City.
Clearsite	Cellulose acetate containers	Hygienic Tube & Container Co., Newark, N. J.
Codur	Synthetic baking enamel	Maas & Waldstein Co., Newark, N. J.
Crystalex	Methacrylate denture compound	Detroit Dental Mfg. Co., Detroit, Mich.
Crystolex	Acrylic denture base	Röhm & Haas Co., Philadelphia, Pa.
Denturol	Phenolic (dentures)	The S. S. White Dental Mfg. Co., Philadelphia, Pa.
Duragrade	Fire extinguisher	Pyrene Mfg. Co., Newark, N. J.
Duranol	Displays, boxes, fancy goods	Joseph H. Meyer Bros., New York City.
Ethofoil	Ethyl Cellulose Film	Dow Chemical Co., Midland, Mich.
Finest	Combs, bag handles, knitting pins	E. B. Kingsman Co., Leominster, Mass.
Flexowax	Synthetic wax	Glyco Products Co., New York City.
Flor-S-Ent	Plastic golf tee	American Molded Products Co., Chicago, Ill.
Fosta	Sun goggles	Foster Grant Co., Inc., Leominster, Mass.
Ganoware	Molded restaurant equipment	George Morrell Corporation, Muskegon Hts., Mich.
Gemlite	Acetate, Methacrylate and Styrene (decorative plastic)	Gemloid Corporation, Elmhurst, L. I., New York.

Miscellaneous—(Continued)

TRADE NAME	DESCRIPTION	MANUFACTURER
Glo Plates	Luminous switch plates	Atlantic Plastics, Cleveland, Ohio.
Glycene	Alkyd denture	Bakelite Corporation, New York City.
Hycoloid	Cellulose nitrate containers	Hygienic Tube & Container Co., Newark, N. J.
Imperial	Plastic hardware	Imperial Molded Products Corp., Chicago, Ill.
Inceloid	Acetate packaging material	American Products Mfg. Co., New Orleans, La.
Irv-O-Lite	Plastic tubing	Irvington Varnish & Insulator Co., Irvington, N. J.
Kemgo	Inks for use with heat	Markem Machine Co., Keene, N. H.
Kodapak	Transparent cellulose acetate foil	Eastman Kodak Co., Rochester, N. Y.
Kogene	Synthetic-elastic rubber derivatives	The B. F. Goodrich Co., Akron, Ohio.
Koroseal	Polyvinyl Chloride (synthetic elastic material)	The B. F. Goodrich Co., Akron, Ohio.
Lucitone	Methacrylate denture compound	L. D. Caulk Co., Milford, Del.
Lumarith-Protectoid	Cellulose acetate (films and foils)	Celanese Celluloid Corporation, New York City.
Lumarith Clair de Lune	Cellulose acetate (lamp shade material)	Celanese Celluloid Corporation, New York City.
Lusteroid	Containers	Lusteroid Container Co., Inc., South Orange, N. J.
Luxene	Phenolic denture	Bakelite Corporation, New York City.
Mir-Con	Laminated Phenolic paper base	Detroit Paper Prod. Corporation, Detroit, Mich.
Nylon	Filaments for brush bristles	E. I. du Pont de Nemours & Co., Inc., Plastics Dept., Arlington, N. J.
Paradura	Phenolic (coatings, safety glass layers)	Paramet Chemical Corporation, Long Island City, New York.
Paragon	Cabinet hardware	Paragon Molded Plastics, Inc., Seattle, Wash.

Miscellaneous—(Continued)

TRADE NAME	DESCRIPTION	MANUFACTURER
Peerless	Insulation fish paper	National Vulcanized Fibre Co., Wilmington, Del.
Plastibraid	Braided plastics	Schwab & Frank, Inc., Detroit, Mich.
Plasticends	Fluorescent lighting enclosures	Industrial Design Associates, East Rutherford, N. J.
Plastico Posmoulage	Reproduction wax	Warren-Knight Co., Philadelphia, Pa.
Plastik Foil	Roll leaf for plastics	Peerless Roll Leaf Co., Inc., Union City, N. J.
Plastitube	Cellulose acetate tube	Schwab & Frank, Inc., Detroit, Mich.
Polaroid	Cellulose acetate (light-polarizing sheet)	Polaroid Corporation, Boston, Mass.
Proxyl	Pyroxylin denture	Lee S. Smith & Son Mfg. Co., Philadelphia, Pa.
Pyralart	Combs and sun goggles	Foster, Grant Co., Inc., Leominster, Mass.
Pyrene	Fire extinguisher	Pyrene Mfg. Co., Newark, N. J.
Resovin	Vinyl denture	S. S. White Dental Mfg. Co., Philadelphia, Pa.
Revolite	Cloth impregnated with phenolic resin	Revolite Div., Atlas Powder Co., Stamford, Conn.
Rexenite	Plastic thread and tape	The Rex Co., Inc., Cambridge, Mass.
RHoplex	Acrylic resin for textile finishes	Röhm & Haas Co., Inc., Philadelphia, Pa.
Ripl-Flo	Vibrating screens	Allis-Chambers Mfg. Co., Milwaukee, Wis.
Saflex	Vinyl acetal safety glass	Monsanto Chemical Co., Plastics Division, Springfield, Mass.
Samson	Pyroxylin film base	Celanese Celluloid Corporation, New York City.
Stratford	Fountain pens and pencils	Salz Brothers, Inc., New York City.
Tag	Thermometers and controllers	C. J. Tagiabue Mfg. Co., Brooklyn, New York.

Miscellaneous—(Concluded)

TRADE NAME	DESCRIPTION	MANUFACTURER
Tilco	Hair ornaments, bag frames, buttons and needlework supplies	Tilton & Cook Co., Leominster, Mass.
Vernonite	Acrylic denture base	Röhm & Haas Co., Inc., Philadelphia, Pa.
Vinal	Vinyl acetal resin for safety glass	Carbide & Carbon Chemicals Corp., New York City.
Vue-Pak	Acetate packaging material	Monsanto Chemical Co., Plastics Division, Springfield, Mass.

Appendix B

Equipment and Supplies

The authors have found certain tools and materials especially useful in fabricating small articles from synthetic plastics. No attempt is made to draw any hard-and-fast line between those woodworking and metal-working tools which may be used and those which may not be used; for, as has been indicated before, almost any tool in these two groups may be used for some operation on a plastics material. Any one of the items occurring in the following lists is not essential before *any* work may be done. These items have been included, however, in order that a large field of operations may be made possible for those who possess all of the items.

The list of hand tools suggested is made up from the tools used in preparation of the projects for this book. The size of the laboratory and the nature of the work will determine the most necessary items. The machine-tool equipment has been arranged in its order of usefulness. Attachments for each machine have been arranged in a similar manner. Plastics, abrasives, and fastening devices have been grouped under "supplies." Selections may be made according to the need. Since cast resinoids are manufactured in almost unlimited sizes, shapes, and colors only a tentative list has been provided. Due to the rapid changes taking place, it is suggested that for quantity orders, price sheets should be obtained from the company before orders are placed. These are usually complete, giving colors, sizes and shapes.

A cross-section of the tools, equipment, and operations used thus far will cover a rather wide range. Many of our old tools have been adapted to new uses on a new material. New machines have been designed to meet the demand for fabricating these materials. For convenience the supplies and equipment have been grouped under special headings and a director of manufacturers and dealers has been included.

Hand Tools

Try square
Sliding T-bevel
Framing square
Combination square
Miter square and blade
24″ steel rule
12″ steel rule
6″ steel rule (16ths-64ths)
Back saw
Coping saw
Hack saw
Jeweler's saw frame
Hand drill
Brace
Miter box
$\frac{1}{4}''$ wood-boring bit
$\frac{5}{16}''$ wood-boring bit
$\frac{3}{8}''$ wood-boring bit
Scratch awl
Scriber
Block plane
Smoothing plane
Marking gauge (with spur point)
Putty knife
Block knife
Carving chisels
Engraving tools
Spring dividers
Compass
6″ inside calipers
6″ outside calipers
Electrician's screwdriver
3″ screwdriver
Hand screws
C-clamp
Bench vise
Bench hook
Swivel bench vise
Hand vise
Slip stone
Prick punch
Center punch
Nail set
$\frac{1}{2}''$ machine countersink (60 degrees)
$\frac{1}{2}''$ machine countersink (82 degrees)
File card
Soft-face hammer
Ball-pein hammer
Tin snips (2″ cut)
Pocket snips ($1\frac{3}{4}$)
Irregular curves
Side cutting pliers
Set of needle files
10″ single cut, smooth, flat file
10″ double cut, second cut file
6″ single cut, smooth, flat file
6″ single cut, smooth, half round file
6″ smooth, round file
$\frac{3}{4}''$-16 plug tap
$\frac{3}{4}''$-16 die
$\frac{1}{2}''$-20 plug tap
$\frac{1}{2}''$-20 die
$\frac{3}{8}''$-24 plug tap
$\frac{3}{8}''$-24 die
$\frac{1}{8}''$ pipe tap
$\frac{1}{8}''$ pipe die
$\frac{5}{16}''$-18 plug tap
$\frac{5}{16}''$-18 die
$\frac{1}{4}''$-20 plug tap
$\frac{1}{4}''$-20 die
$\frac{3}{16}''$-32 plug tap
$\frac{3}{16}''$-32 die
8-32 plug tap
8-32 die
6-32 plug tap
6-32 bottoming tap
6-32 die
Die holder
Tap wrench
$\frac{1}{8}''$ drill and countersink
$\frac{3}{32}''$ drill and countersink
$\frac{11}{16}$ straight shank twist drill
Nos. 55, 51, 49, 47, 45, 38, and 31 straight shank, straight fluted twist drills
Set of straight shank, twist drills ($\frac{1}{16}''$-$\frac{1}{2}''$ by 64ths)

Machine Tools

A. Jig saw
   1. Ripping fence
   2. Machine files
   3. Routing attachment (desirable)
   4. High-speed flexible shaft attachment (desirable)

B. Polishing heads
   1. $6'' \times 1'' \times \frac{1}{2}''$ sewed muslin buffing wheel
   2. $6'' \times 1'' \times \frac{1}{2}''$ loose muslin buffing wheel
   3. $6'' \times 1'' \times \frac{1}{2}''$ loose flannel buffing wheel

C. Disc sander
   1. Miter gauge

D. Wood lathe
   1. $\frac{1}{2}''$ round nose tool
   2. Parting tool
   3. $\frac{1}{2}''$ skew chisel
   4. $\frac{1}{4}''$ round nose tool
   5. $\frac{1}{4}''$ skew chisel
   6. $1''$ skew chisel
   7. Jacob's chuck to fit head and tail stocks
   8. $3''$ face plate with spurs and changeable center
   9. $6''$ face plate
   10. Grinding wheel arbor
   11. Universal 3-jaw chuck with back plate

E. Metal lathe
   1. $5''$ universal 3-jaw chuck
   2. Right-hand, off-set tool holder
   3. Bar of high speed steel for cutters
   4. Jacob's chuck to fit head-stock spindle
   5. Adapter for tail stock
   6. Cutting-off tool
   7. Left-hand, off-set tool holder
   8. Boring tool
   9. Drill and countersink ($\frac{3}{10} \times \frac{1}{8}$)

F. Belt sander
   1. Stop guard

G. Drill press
   1. Set of straight shank twist drills ($\frac{1}{16}''$-$\frac{1}{2}''$ by 64ths)
   2. $1\frac{1}{2}''$ sanding drum
   3. $2''$ sanding drum
   4. $2\frac{1}{2}''$ sanding drum
   5. Machine countersink (60 deg.)

H. Spindle carver
   1. Cutters as needed

I. Rotary tool
   1. Set of accessories

Supplies

Abrasives

No. 2 garnet paper, electro-coated
No. $1\frac{1}{2}$ garnet paper, electro-coated
No. 1 garnet paper, electro-coated
No. $\frac{1}{2}$ garnet paper, electro-coated
No. 0 waterproof garnet paper
No. 3-0 waterproof garnet paper
No. 7-0 waterproof garnet paper
FF pumice stone
Emery
Garnet
Aluminum oxide
FFF pumice stone
Silica
Lea Compound Grade "C"
Lea Compound Grade "S"
Tripoli
Rouge
Chalk
Learok Grade S-28
Learok Grade 119
Learok Grade 436
Lime
Rotten stone

Supplies—(Continued)

Nu-white
Learok Grade 304-B
Learok Grade 746
Learok Grade 766

Fastening devices
A. Machine screws
$6\text{-}32 \times \frac{3}{4}''$ flat head
$6\text{-}32 \times \frac{3}{4}''$ round head
$6\text{-}32 \times \frac{3}{4}''$ oval head
$8\text{-}32 \times 1''$ flat head
$8\text{-}32 \times 1''$ round head
B. Drive screws
No. $00 \times \frac{1}{8}''$ round head
No. $00 \times \frac{3}{16}''$ round head
No. $00 \times \frac{1}{4}''$ round head
No. $0 \times \frac{5}{16}''$ round head
No. $6 \times \frac{3}{8}''$ flat head
C. Self-tapping screws
No. $2 \times \frac{3}{8}''$ flat head
No. $4 \times \frac{5}{8}''$ flat head

Metal findings
$1''$ bar pins (for drive screws)
$1\frac{1}{2}''$ bar pins (for drive screws)
Dress clasps
Spring clasps
Buckle catches
Hinges
Spring hinges
Badge pins
Earring mountings

Adhesives
Acetate cement
Opaque plastics cement
Transparent cement
Accelerator
"No. 94 Water-Resistant Adhesive" (Williamson)
"Cascamite"

Saw Blades (assorted sizes)
Jig saw
Coping saw
Fret saw
Jeweler's saw

Miscellaneous supplies
Glass mixing rod and plate
Ethyl alcohol
Cutting oil
Paraffin oil
Commercial hydrochloric acid diluted with 25 per cent distilled water

Common sizes of cast resinoids (Catalin)
A. Sheets $(12'' \times 24'')$
$\frac{1}{8}''$
$\frac{3}{16}''$
$\frac{1}{4}''$

$1''$ in thickness
B. Round rods (standard molds)
$\frac{1}{4}''$
$\frac{5}{16}''$
$\frac{3}{8}''$
$\frac{1}{2}''$
$\frac{5}{8}''$
$\frac{3}{4}''$
$1''$
$1\frac{1}{4}''$
$1\frac{1}{2}''$ in diameter
C. Square rods
$\frac{1}{4}''$
$\frac{5}{16}''$
$\frac{3}{8}''$
$\frac{1}{2}''$
$\frac{5}{8}''$
$\frac{3}{4}''$
$1''$
$1\frac{1}{4}''$
$1\frac{1}{2}''$
D. Cylinders
$1''$ O.D. $\times \frac{1}{2}''$ I.D.
$1\frac{7}{32}''$ O.D. $\times \frac{3}{4}''$ I.D
$1\frac{3}{8}''$ O.D $\times \frac{1}{2}''$ I.D.

Supplies—(Concluded)

$1\frac{3}{8}''$ O.D. $\times$ $1\frac{1}{2}''$ I.D.	Elephant
$2''$ O.D. $\times$ $1\frac{1}{2}''$ I.D.	Donkey
$2\frac{3}{4}''$ O.D. $\times$ $2\frac{5}{16}''$ I.D.	Duck
$3''$ O.D. $\times$ $2\frac{5}{8}''$ I.D.	Butterfly
E. Special castings	Anchor
Ring tube	Buckle
Scotty dog	Dachshund

The American Catalin Corporation manufactures 150 different sizes in six shapes, including hexagon and octagon rods in addition to the foregoing. Sheets range from $\frac{1}{8}''$ to $1''$ in thickness; round rods from $\frac{1}{4}''$ to $5\frac{1}{4}''$ in diameter; square rods $\frac{5}{16}''$ to $4''$ on a side may be obtained; octagon rods range from $\frac{11}{32}''$ to $2\frac{9}{16}''$ across flats; hexagon rods measure from $\frac{7}{16}''$ to $2''$ across flats, and cylinders range from $1''$ to $8\frac{7}{8}''$ outside diameter. The above shapes and sizes are found to be most useful.

The Marblette Corporation manufactures a pure synthetic resinoid in all colors. It is sold in sheets, rods, tubes, and special shapes in opaque, translucent and transparent form in either plain or mottled effects. Sheets $\frac{3}{16}''$ to slightly over $1''$ in thickness range in various sizes up to $10''$x$20\frac{1}{4}''$. Round rods $\frac{11}{32}''$ to $6''$ in diameter up to $21\frac{1}{2}''$ in length may be purchased. Square rods $\frac{3}{8}''$ to $4''$ on a side and from $6\frac{1}{8}''$ to $21''$ in length. Seventy-six sizes of cylinders and tubes from $1\frac{5}{16}''$ O.D. to $8\frac{1}{8}''$ O.D. and $3\frac{5}{8}''$ to $12\frac{1}{4}''$ in length are listed. Other shapes are: button rods, backgammon rods, three-leaf clover rods, four-leaf clover rods, triangular rods, five-cornered rods, hexagonal rods, octagonal rods, scalloped rods, quarter rounds, half rounds, and star rods. Marblette "Crystle" is a transparent, water-clear cast phenolic.

Bakelite Corporation manufactures plates $6''$x$18''$ ranging in thickness from $\frac{1}{8}''$ to $2\frac{1}{2}''$. Round rods up to $22.18''$ in length with diameters from $.248''$ to $4.05''$. One hundred sizes are listed. Concentric tubes up to $12.12''$ in length with outside and inside diameters from $.633''$ O.D.x.$415''$ I.D. to $8.827''$ O.D.x$8.273''$ I.D. Square rods $.315''$ to $4.137''$ on a side and up to $22''$ in length. Miscellaneous shaped rods such as hexagonal, octagonal, half round, oval, and curved strips in a wide range of colors are available.

Celluloid Corporation manufactures "Celluloid" and "Lumarith" in sheets, rods, and tubes in assorted colors and gauges. Standard sheets are 20″x50″ and from .003″ to .035″ in thickness. Many colors are available in each from the transparent clear through the opaque, translucent, shell, wood effects, mottles, and pearls. Black and white are also available.

The Parkwood Corporation manufactures "Parkwood Textolite" in $\frac{1}{16}$″ sheets 36″x72″, 24″x108″, and 30″x108″ with stiff sanded back. Flexible fabric back sheets $\frac{1}{28}$″ or .035″ thick are offered in the 30″x108″ size only. Three classes are available: Class 1—Slip matched veneers in mahogany, walnut, prima vera, and maple. Class 2—Woven designs in mahogany, maple, walnut, and prima vera. Strips $\frac{1}{2}$″ to 2″ wide are straight or diagonally woven. Class 3—Woven designs in East Indian rosewood and other foreign woods. Patterns are either straight or diagonally woven.

Table V

Drill Sizes

SCREW DIAMETER	SELF-TAPPING SCREWS		DRIVE SCREWS	
	HOLE DIAMETER	DRILL SIZE	HOLE DIAMETER	DRILL SIZE
No. 00	.....	.....	.052″	No. 55
No. 0	.....	.....	.067″	No. 51
No. 2	.078″	No. 47	.086″	No. 44
No. 4	.099″	No. 39	.104″	No. 37
No. 6	.128″	No. 30	.120″	No. 31
No. 7	.136″	No. 39	.136″	No. 29
No. 8	.149″	No. 25	.144″	No. 27
No. 10	.177″	No. 16	.161″	No. 20
No. 12	.199″	No. 8	.191″	No. 11
No. 14	.234″	$\frac{15}{64}$″	.221″	No. 2

Table VI

Tap-Drill Sizes

NOMINAL SIZE	THREADS PER INCH		TAP-DRILL SIZES			CLEARANCE DRILL SIZE
	NC	NF	TAP-DRILL APPROX. 75% FULL THREAD	DECIMAL EQUIVALENT	NEAREST FRACTIONAL SIZE	
0	. .	80	$\frac{3}{64}$	.0469	$\frac{3}{64}$	51
1	64	. .	53	.0595	$\frac{1}{16}$	47
1	. .	72	53	.0595	$\frac{1}{16}$	47
2	56	. .	50	.0700	$\frac{5}{64}$	42
2	. .	64	49	.0730	$\frac{5}{64}$	42
3	48	. .	47	.0785	$\frac{5}{64}$	36
3	. .	56	45	.0820	$\frac{5}{64}$	36
4	40	. .	43	.0890	$\frac{3}{32}$	31
4	. .	48	42	.0935	$\frac{3}{32}$	31
$5\frac{1}{8}$	40	. .	38	.1015	$\frac{7}{64}$	29
$5\frac{1}{8}$	. .	44	37	.1040	$\frac{7}{64}$	29
6	32	. .	35	.1065	$\frac{7}{64}$	25
6	. .	40	33	.1130	$\frac{1}{8}$	25
8	32	. .	29	.1360	$\frac{9}{64}$	16
8	. .	36	29	.1360	$\frac{9}{64}$	16
10	24	. .	25	.1495	$\frac{5}{32}$	$\frac{13}{64}$
10	. .	32	21	.1590	$\frac{5}{32}$	$\frac{13}{64}$
12	24	. .	16	.1770	$\frac{11}{64}$	$\frac{7}{32}$
12	. .	28	14	.1820	$\frac{3}{16}$	$\frac{7}{32}$
$\frac{1}{4}$	20	. .	7	.2010	$\frac{13}{64}$	$\frac{17}{64}$
$\frac{1}{4}$	. .	28	3	.2130	$\frac{7}{32}$	$\frac{17}{64}$
$\frac{5}{16}$	18	. .	F	.2570	$\frac{17}{64}$	$\frac{21}{64}$
$\frac{5}{16}$	. .	24	I	.2720	$\frac{17}{64}$	$\frac{21}{64}$
$\frac{3}{8}$	16	. .	$\frac{5}{16}$	.3125	$\frac{5}{16}$	$\frac{25}{64}$
$\frac{3}{8}$	. .	24	Q	.3320	$\frac{21}{64}$	$\frac{25}{64}$
$\frac{7}{16}$	14	. .	U	.3680	$\frac{3}{8}$	$\frac{29}{64}$
$\frac{7}{16}$	. .	20	$\frac{25}{64}$	.3906	$\frac{25}{64}$	$\frac{29}{64}$
$\frac{1}{2}$	13	. .	$\frac{27}{64}$	.4219	$\frac{27}{64}$	$\frac{33}{64}$
$\frac{1}{2}$	. .	20	$\frac{29}{64}$	.4531	$\frac{29}{64}$	$\frac{33}{64}$
$\frac{9}{16}$	12	. .	$\frac{31}{64}$	.4844	$\frac{31}{64}$	$\frac{37}{64}$
$\frac{9}{16}$	. .	18	$\frac{33}{64}$	.5156	$\frac{33}{64}$	$\frac{37}{64}$
$\frac{5}{8}$	11	. .	$\frac{17}{32}$	.5312	$\frac{17}{32}$	$\frac{41}{64}$
$\frac{5}{8}$	. .	18	$\frac{37}{64}$	.5781	$\frac{37}{64}$	$\frac{41}{64}$
$\frac{3}{4}$	10	. .	$\frac{21}{32}$	.6562	$\frac{21}{32}$	$\frac{49}{64}$
$\frac{3}{4}$	. .	16	$\frac{11}{16}$	.6875	$\frac{11}{16}$	$\frac{49}{64}$
$\frac{7}{8}$	9	. .	$\frac{49}{64}$	.7656	$\frac{49}{64}$	$\frac{57}{64}$
$\frac{7}{8}$	. .	14	$\frac{13}{16}$	.8125	$\frac{13}{16}$	$\frac{57}{64}$
1	8	. .	$\frac{7}{8}$	.8750	$\frac{7}{8}$	$1\frac{1}{64}$
1	. .	14	$\frac{15}{16}$	.9375	$\frac{15}{16}$	$1\frac{1}{64}$
$\frac{1}{8}$ pipe	N.P.T.	. .	$\frac{11}{32}$	.3437	$\frac{11}{32}$	$\frac{27}{64}$

Supplies and Equipment Directory

ABRASIVES

Brodhead-Garrett Co.,
4560-4570 E. 71st St.,
Cleveland, Ohio.

Carborundum Company,
Niagara Falls, N. Y.

Lea Manufacturing Company,
Waterbury, Conn.

Norton Company,
125 Barclay St.,
New York City.

BUFFING AND POLISHING COMPOUNDS AND BUFFING WHEELS

American Rotary Tools Company, Inc.,
44 Whitehall St.,
New York City.

Brodhead-Garrett Co.,
4560-4570 E. 71st St.,
Cleveland, Ohio.

Bruce Products Corporation,
5712 Twelfth St.,
Detroit, Mich.

E. I. Dupont de Nemours & Co., Inc.,
Wilmington, Delaware.

Lea Manufacturing Company,
Waterbury, Conn.

Chicago Wheel and Mfg. Co.,
1107 West Monroe St.,
Chicago, Illinois.

Lupomatic Tumbling Machine Co., Inc.,
4510 Bullard Ave.,
New York City.

Sears, Roebuck & Co.,
Chicago, Illinois.

CARVING, HAND

Craftsman Wood Service Co.,
2729 S. Mary St.,
Chicago, Illinois.

Millers Falls Co.,
Greenfield, Mass.

William Dixon, Inc.,
32 East Kinney St.,
Newark, N. J.

CARVING, POWER

American Rotary Tools Co., Inc.,
44 Whitehall St.,
New York City.

CEMENTS

Brodhead-Garrett Co.,
(Catalin or "Garalin")
4560-4570 E. 71st St.,
Cleveland, Ohio.

Casein Company of America,
("Cascamite")
350 Madison Ave.,
New York City.

Catalin Corporation, (Catalin)
One Park Avenue,
New York City.

Celluloid Corporation, (Acetate)
180 Madison Ave.,
New York City.

Fanwood Specialties Co.,
(Abrasive Discs)
Plainfield, N. J.

Marblette Corporation, (Marblette)
37-21 Thirtieth St.,
Long Island City, N. Y.

Trafford Modern Materials,
[Trafford cement (Phenolic), acetate, special adhesive]
360 Worthington Street,
Springfield, Mass.

U. S. Plywood Corporation,
("Weldwood" for laminates)
616 West 46th St.,
New York City.

Williamson Adhesives, Inc.,
2327 West Eighteenth St.,
Chicago, Illinois.

EDUCATIONAL DISPLAYS

The Story of Plastics—An educational plastics kit.

Supplies and Equipment Directory—(Continued)

Bakelite Corporation,
30 E. 42nd Street,
New York City.

FINDINGS AND SUPPLIES

American Brass Co.,
Waterbury, Conn.

Atlas Findings Co.,
226 Eddy St.,
Providence, Rhode Island.

Brodhead-Garrett Co.,
4560-4570 E. 71st St.,
Cleveland, Ohio.

Strathmore Co.,
31 Commercial St.,
Edgewood, Rhode Island.

Tinnerman Products, Inc.,
2048 Fulton Road,
Cleveland, Ohio.

Whitaker-Fielding Co.,
35 Baker St.,
Providence, Rhode Island.

Wrot Iron Designers,
541 West 35th St.,
New York City.

HAND TOOLS

Goodell Pratt Company,
Greenfield, Mass.

L. S. Starrett Co.,
Athol, Mass.

Lussky, White & Coolidge, Inc.,
65-71 W. Lake St.,
Chicago, Illinois.

Millers Falls Co.,
Greenfield, Mass.

Montgomery Ward & Co.,
Chicago, Illinois.

Sears, Roebuck & Co.,
Chicago, Illinois.

Stanley Rule and Level Co.,
New Britain, Conn.

William Dixon, Inc.,
32 E. Kinney St.,
Newark, N. J.

MACHINES: BUFFING AND POLISHING

American Rotary Tools Co., Inc.,
44 Whitehall St.,
New York City.

Brodhead-Garrett Co.,
4560-4570 E. 71st St.,
Cleveland, Ohio.

Chicago Wheel and Mfg. Co.,
1107 West Monroe St.,
Chicago, Illinois.

Delta Manufacturing Co.,
661-N East Vienna Ave.,
Milwaukee, Wisconsin.

Hanson-VanWinkle-Munning Co.,
Matawan, N. J.

Lea Manufacturing Co.,
Waterbury, Conn.

Lupomatic Tumbling Machine Co., Inc.,
4510 Bullard Ave.,
New York City.

Walker-Turner, Inc.,
Plainfield, N. J.

William Dixon, Inc.,
32 East Kinney St.,
Newark, N. J.

MACHINES: FACETING AND GEM CUTTING

Magada Studios,
55 Dey Street,
New York City.

Warner and Greiger,
405 Ninita Parkway,
Pasadena, California.

PLASTICS, CAST RESINOIDS

"Amberol"	Fellowcrafters, Inc., 64 Stanhope St., Boston, Mass.
"Bakelite"	Bakelite Corporation, 30 E. 42nd St., New York City.
"Catalin"	Fanwood Specialties Co., Box C-56 Scotch Plains, N. J.

Supplies and Equipment Directory—(Continued)

"Craftene" Craft Service,
360 Union Ave.,
Rochester, N. Y.

"Craftsman" Craftsman Supply House,
Scottsville, N. Y.

"Garalin" (Catalin) Brodhead-Garrett Co.,
4560-4570 E. 71st St.,
Cleveland, Ohio.

"Marblette" The Marblette Corp.,
37-21 Thirtieth St.,
Long Island City, N. Y.
(Sold in lots of not less than 50 pounds)

"Trafford" Trafford Modern Materials,
360 Worthington St.,
Springfield, Mass.

PLASTICS, CELLULOSE

"Bakelite" Bakelite Corporation,
30 E. 42nd St.,
New York City.

"Celluloid" Celluloid Corporation,
10 E. 40th St.,
New York City.

"Lumarith" Celluloid Corporation,
10 E. 40th St.,
New York City.

PLASTICS, LAMINATED

"Formica" Formica Insulation Co.,
4671 Spring Grove Ave.,
Cincinnati, Ohio.

"Textolite" General Electric Co.,
Plastics Dept.,
1 Plastics Ave.,
Pittsfield, Mass.

POWER MACHINERY

Atlas Press Company,
Kalamazoo, Michigan.

Brodhead-Garrett Co.,
4560-4570 E. 71st St.,
Cleveland, Ohio.

Crescent Machine Co.,
Leetonia, Ohio.

Delta Manufacturing Co.,
661-N East Vienna Ave.,
Milwaukee, Wisconsin.

Oliver Machinery Company,
Grand Rapids, Michigan.

Sears, Roebuck & Co.,
Chicago, Illinois.

South Bend Lathe Works,
South Bend, Indiana.

Walker-Turner, Inc.,
Plainfield, N. J.

Yates-American Machine Co.,
Beloit, Wisconsin.

PRESSES, LABORATORY

Fred S. Carver,
343 Hudson St.,
New York City.

Hydraulic Press Mfg., Co.,
Mount Gilead, Ohio.

Standard Tool Co.,
73-75 Water Street,
Leominster, Mass.

Stokes Machine Co., F. J.
5935 Tabor Road,
Olney P. O.
Philadelphia, Pa.

ROTARY TOOLS

Chicago Wheel and Mfg. Co.,
1107 West Monroe St.,
Chicago, Illinois.

Dremel Mfg. Co.,
Racine, Wisconsin.

Sears, Roebuck & Co.,
Chicago, Illinois.

William Dixon, Inc.,
32 East Kinney St.,
Newark, N. J.

SCREWS, DRIVE AND SELF-TAPPING

Brodhead-Garrett Co.,
4560-4570 E. 71st St.,
Cleveland, Ohio.

Fellowcrafters, Inc.,
64 Stanhope St.,
Boston, Mass.

Supplies and Equipment Directory—(Concluded)

Parker-Kalon Corporation,
192-198 Varick Street,
New York City.

Strathmore Company,
31 Commercial St.,
Edgewood, Rhode Island.

The Cleveland Tool and Supply Co.,
1427-1437 West Sixth St.,
Cleveland, Ohio.

SHAPERS AND ROUTERS

American Rotary Tools Co., Inc.,
44 Whitehall St.,
New York City.

Carter Div., R. L.,
The Stanley Works,
New Britain, Conn.

Chicago Wheel and Mfg. Co.,
1101 West Monroe St.,
Chicago, Ill.

Rotary Tool and Machine Co.,
217 E. 38th St.,
New York City.

Royle & Sons, John,
10 Essex St.,
Paterson, N. J.

Stanley Rule and Level Co.,
New Britain, Conn.

Wallace Co., J. D.,
140 S. California St.,
Chicago, Illinois.

Walker-Turner, Inc.,
Plainfield, N. J.

Educational Institutions Directory

PLASTICS CHEMISTRY

University of Alabama,
Tuscaloosa, Alabama.

Plastics Industries Technical Institute
186 S. Alvarado Street,
Los Angeles, California.

Illinois Institute of Technology
Chicago, Illinois.

University of Maine,
Orono, Maine.

Boston Technical Institute
620 Commonwealth Avenue,
Boston, Massachusetts.

Michigan State College of Agriculture and Applied Science,
East Lansing, Michigan.

School of Technology,
College of the City of New York,
Convent Avenue and 139th Street,
New York City.

Department of Chemical Engineering,
Columbia University,
630 West 168th Street,
New York City.

College of Engineering,
New York University,
University Heights,
New York City.

Department of Engineering and Chemistry,
Rensselaer Polytechnic Institute,
Troy, New York.

John Carroll University,
University Heights,
Cleveland, Ohio.

Engineering College,
University of Toledo,
Toledo, Ohio.

Mellon Institute of Industrial Research,
University of Pittsburgh,
Pittsburgh, Pennsylvania.

Agricultural Experiment Station,
University of Tennessee,
Knoxville, Tennessee.

McGill University,
Montreal, Canada.

Educational Institutions Directory—(Continued)

PLASTICS DESIGN

California Institute of Technology,
Pasadena, California.

Plastics Industries Technical Institute,
186 S. Alvarado Street,
Los Angeles, California.

Department of Education,
Bureau of Vocational Education,
State Trade School,
Stamford, Connecticut.

Lake Forest Academy,
Lake Forest, Illinois.

School of Design in Chicago,
247-57 East Ontario Street,
Chicago, Illinois.

Boston Technical Institute
620 Commonwealth Avenue,
Boston, Massachusetts.

Engineering College,
University of Toledo,

Rhode Island School of Design,
Providence, Rhode Island.

Layton Art Gallery,
Layton School of Art,
Milwaukee, Wisconsin.

VOCATIONAL PLASTICS

Plastics Industries Technical Institute,
186 S. Alvarado Street,
Los Angeles, California.

Boston Technical Institute,
620 Commonwealth Avenue,
Boston, Massachusetts.

Appendix C

Glossary

ASHING. The operation of cutting down a surface by means of a coarse abrasive (usually pumice) applied to a revolving cloth wheel.

BITUMEN. Any of a series of native hydrocarbons which are in solid form. The term commonly refers to cold-molded plastics which are insoluble in water but soluble in carbon disulphide, and which are produced from hydrocarbons.

BUFFING. The operation of producing a smooth, uniform surface by additional smoothing beyond the roughing operation or of providing a glossy surface by the use of a buffing wheel coated with a fine, sharp abrasive compound. Whether or not this is the final finishing operation is determined by the gloss desired.

BUFFING WHEEL. A wheel made up of flexible paper, cloth, or sheepskin discs and mounted on an arbor or polishing head.

CAST RESINOIDS. As the name indicates, they are castings made from synthetic materials. Sheets, rods, tubes, and special shapes are made in the range of sizes most commonly used by fabricators. Plastics in these shapes enable a manufacturer to fabricate many articles with equipment which is of a nature more common than molding equipment and much less expensive. Both woodworking and metal-working machines are used to advantage.

CATALYST. A substance such as hexamethylenetetramine (Hexa), which is used in thermosetting resinoids to initiate or accelerate the chemical action necessary to combine the basic materials into one new unit; it does not combine with either of these materials and does not undergo any permanent change itself.

COLD MOLDING. A molding procedure whereby a composition is molded at ordinary room temperatures and cured by an application of heat after removal from the press.

COLORING. This is the final finishing operation. The operation is performed on a loose muslin or flannel buffing wheel to which a high lustre or mild buffing compound has been applied. (It gets its name from the fact that a coloring pigment to match the polished surface is often included in the compound to provide additional lustre.)

CURING. The change by chemical action which transposes a resinoid binder from a fusible-soluble mass to an infusible-insoluble mass; an action analogous to the vulcanization of rubber.

Extrusion Molding. A molding procedure whereby a heat-softened substance is forced through an orifice to produce an extruded shape possessing a cross-section which conforms to the shape of the orifice.

Fabrication. The art of constructing, manufacturing, or building an article.

Facet. Any of several plane surfaces cut on gems or the operation of cutting several small surfaces on a precious stone such as a diamond. It may be applied to plastics.

Flute. A concave channel cut in posts, columns, legs, edges, and small plane surfaces—a design feature chiefly.

Formaldehyde. A gas possessing a pungent odor, usually existing in a water solution. It is commonly obtained by passing the vapors of partially oxidized alcohol over finely divided particles of copper or platinum which act as a catalyst and produce a chemical change (partial oxidation). The resultant gas is dissolved in water. A commercial "40 per cent formalin" solution is used in the production of phenol-formaldehyde resinoids and urea-formaldehyde resinoids.

Injection Molding. A molding procedure whereby a heat-softened substance from a heated cylinder is forced into a comparatively cool cavity where it hardens in a conforming shape.

Kerf. The notch or slit made by a saw as it cuts through plastics, wood, metal, and other materials.

Laminated. A dictionary defines the term as material "consisting of or arranged in layers of thin plates, one upon the other." In the plastics industry, it means a dense, solid, strong material produced by applying heat and pressure to super imposed layers of materials such as paper or fabric which is impregnated with a resinoid.

Laminated Plastics. Sheets of material built up from layers of resinoid and other materials such as paper, fabric, and plywood. Synthetic plastics film is used for bonding these materials together in layers. Laminated panels are produced for use in building construction. Paper and resinoid are laminated in the shape of tubes and rods by rolling the impregnated paper over a form after which they are allowed to cure in an oven. Impregnated fabric layers may be bonded together into a solid mass from which gears and similar parts are made.

Molded Plastics. This group of materials includes those articles which are fabricated from various types of molding powder in expensive and massive presses. The die molds used require expensive preparation because the molded article must come from the die with a finished surface. For this reason the surface of a die must be very smooth. Heat accompanies most molding operations. The molding powder is placed in a mold by one of a number of methods; pressure ranging from 1,000 to 10,000 pounds per

square inch is applied; and the article is allowed to cure partially while in the mold. Thermoplastic resinoids must have a cooled mold before the molded article can be removed from the mold or before it will set. Thermosetting compositions cure in molds while they are still hot. Molding compounds may be made from pure resinoid containing suitable catalysts, or they may contain some quantity of filler such as wood flour, mineral filler, cotton flock, diatomaceous silica, and asbestos.

Phenol. One of a series of compounds, liquid and solid, which are derivations of hydrocarbons; a by-product of coal tar produced in the coke oven. It may be prepared synthetically by indirect oxidation of benzol as well as by other methods. The most common known phenol is carbolic acid. It may appear on the market in the form of white crystals.

Plastic. An adjective meaning "capable of being formed or molded."

Plasticizer. A substance such as dibutyl phthalate, diethyl phthalate, or dimethyl phthalate which is used both in thermosetting and thermoplastic resinoids. It acts as a softening agent as it combines with the base materials to prevent permanent infusibility.

Plastics. A noun which refers to any of a variety of organic compounds, usually synthetic, which are at one stage a liquid and at another a solid. Thermoplastics and thermosetting compounds are included. Hardening is accomplished by cooling, by curing, or by hardening agents. All types of plastics can be molded. Special treatment enables some types to be cast. Hardening or curing usually brings about a rearrangement of molecules to produce a new compound.

Plastics. An adjective meaning "made of plastics."

Polishing Wheel. A wheel made up of layers of fiber of varying degrees of flexibility upon which alternate layers of abrasives and glue are applied; it is mounted on an arbor or polishing head.

Polymerization. The term applies to the chemical change which takes place in the manufacture of certain resinoids and which results in the formation of a new compound with a molecular weight that is a multiple of that of the original substance. The phenol formaldehyde and urea-formaldehyde resinoids furnish examples of polymerization.

Rake. The slant or slope from the horizontal or perpendicular line found on cutting tools. It is taken with reference to the plane of contact when a cut is made. All woodworking and most metal-working tools, for example, have a positive rake or form an angle of more than 90 degrees with the point of contact.

Resin. Any of a class of uncrystallizable vegetable substances produced by hardening or drying secretion exuding from certain plants; soluble in alcohol, turpentine, benzine, etc., but not in water. A term generally referring to all *natural* substances which, within a particular range of temperature, show the properties just mentioned.

RESINOID. A resinous substance; a class name applied to temporary thermoplastics or thermosetting plastics to distinguish them from natural resins. This term applies only to synthetic or man-made materials.

"A"—STAGE RESINOID. Thermosetting resinoids occur in three stages. In the "A" stage, the resinoid will dissolve in alcohol and acetone solvents and can be melted.

"B"—STAGE RESINOID. This stage is produced by heating raw resinoid for about an hour at 95 to 100 degrees Centigrade or (68-21) "for two or three minutes at 130 degrees Centigrade." It is leather-like and is almost insoluble in alcohol and acetone solvents.

"C"—STAGE RESINOID. Additional heat, either at higher temperatures or for longer periods of time, changes the "B" stage resinoid to the final stage where polymerization is complete. The characteristic of "heat irreversibility" renders the plastics infusible and insoluble in this stage. In its unadulterated state, phenolic resinoid is amber in color.

SANDING.—The operation which involves the rapid cutting down of a surface either by an abrasive polishing wheel or by hand with the various grades of abrasive papers.

SYNTHETIC RESIN. A misnomer. A term commonly applied to complex organic compounds built up by chemical action from simple compounds into a solid or semi-solid material.

In the dictionary sense, "resin" applies to *natural resins* while "resinoid" applies to *man-made* materials.

THERMOPLASTIC. The property possessed by certain plastics of softening under heat. This class of plastics (thermoplastics) remains permanently soft under heat, but the other class (thermosetting) cures to a solid form under heat. At normal temperatures, the thermoplastic remains rigid.

THERMOSETTING. The property of undergoing a chemical change from the application of heat whereby a hardened material is obtained. This property is pronounced in phenol-formaldehyde and urea-formaldehyde resinoids. Originally these materials are thermoplastics but become permanently infusible from the application of heat. The heating over a period of time results in "curing."

UREA. The base of urea-formaldehyde resinoids; "a white, highly soluble, crystalline substance, one of the final products of oxidation of the nitrogenous compounds of the human body, found abundantly in the urine of mammals." It is made synthetically by heating carbon dioxide and ammonia at high pressures.

WIND. An abnormal twisted shape in a plastics, wood, or metal solid which results from a strain placed on the molecules or fibers of the material which is brought about by uneven moisture or heat application.

Appendix D

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